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FIG. 1.—THE STATUE OF LIBERTY, NEW YORK.

THE STATUE OF LIBERTY, NEW YORK.

October 28, 1886, the day fixed for the public inauguration of this great work, will be memorable in the history of the metropolis of the New World. The assembly of distinguished personages, the official ceremonies, and the great pageant pertaining to the inauguration will have a widespread interest. For the special particulars of these, reference must be had to the daily newspapers. As to the work itself, its history, progress, and construction, we will here present a brief account.

The incipient, moving cause that gave origin to the work appears to have been due to the eloquent and suggestive ideas and expressions of M. Laboulaye, given many years ago to his particular friend M. Bartholdi, the sculptor. The actual scheme for the realization of the work was privately formulated within the circle of Bartholdi's friends in 1870. The plan for a popular subscription in France for the construction of the statue was made public in 1874; and thereafter various festivals were held for raising the money and the work was commenced. In 1876 a portion of the statue, the hand bearing the torch, was completed, sent to this country, and exhibited at the great exposition, Philadelphia, in 1876, and subsequently in New York. The act of Congress accepting the statue as a gift from the French people, and setting apart Bedloe's Island, in New York Harbor, as the place for its reception, was passed in 1877. Another portion of the statue, the head, was completed and put on exhibition at the Paris exposition in 1878.

The statue was wholly completed in 1883, and in the same year the building of the great pedestal on which the statue stands was begun on Bedloe's Island. The statue was formally delivered into the hands of the United States Minister in France, July 4, 1884, and in June, 1885, was brought over in a French war vessel, and landed in New York. The work of finishing the pedestal and erecting the statue thereon was completed in October, 1886. Such, in brief, is the chronology of this interesting work.

We give a series of engravings from which a fair idea of the appearance and nature of the structures can be gathered. Our front page engraving (Fig. 1) shows the appearance of the great statue, as it stands completed, on the little island of Bedloe, in New York bay, just at the mouth of the noble Hudson River, a short distance from where it issues from the rocky southern extremity of the long barrier known as the Palisades. The position of the statue is a very commanding one; it overlooks the great bay of New York in all directions, and is in plain view from the cities of New York, Brooklyn, Jersey City, Newark, and other large towns.

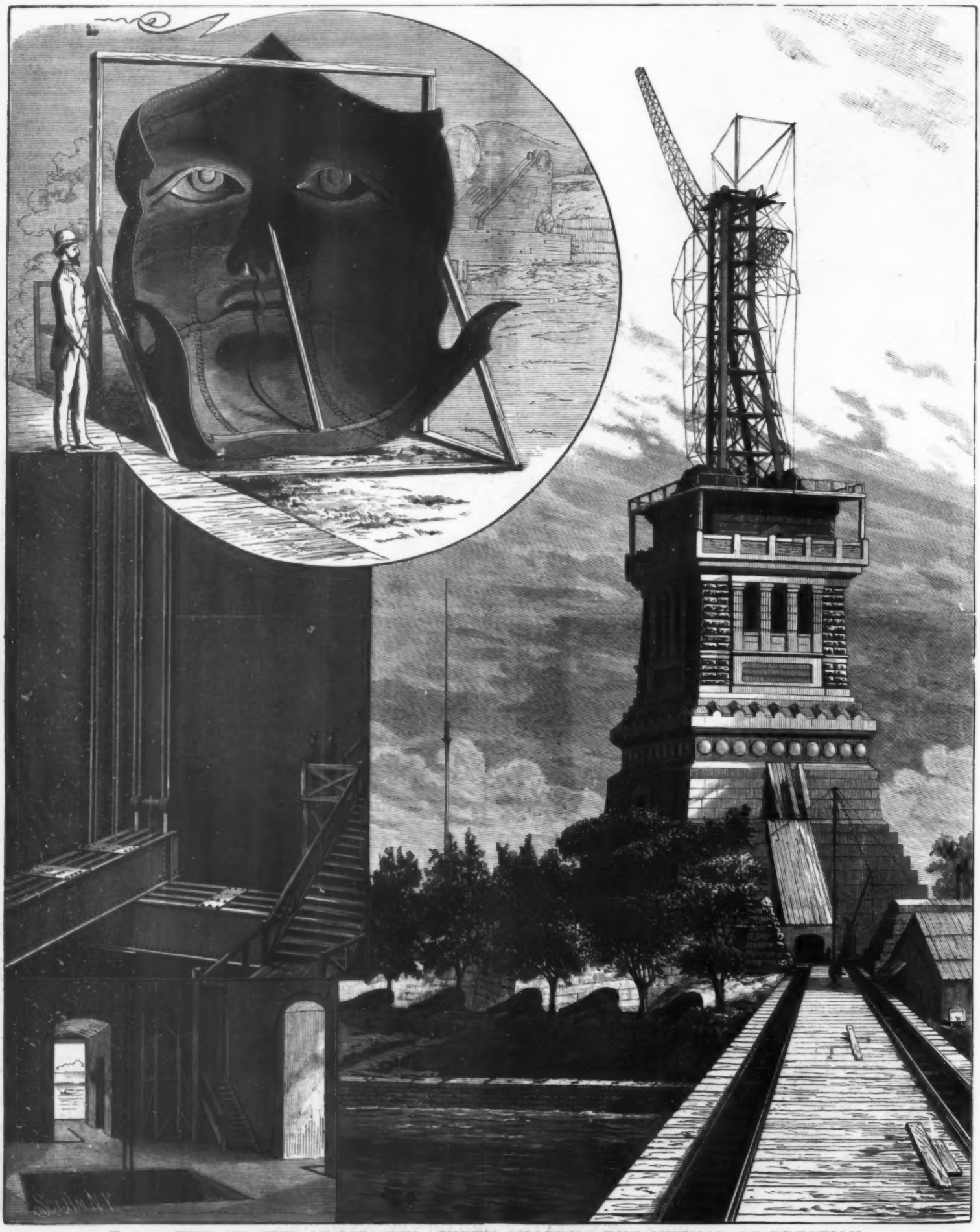


Fig. 2.—THE STATUE OF LIBERTY.—VIEWS SHOWING THE METHOD OF ERECTION.

The pedestal is 149 ft. 10 in. high above water level. The statue is 151½ ft. high. Total height of statue above water level, 301¼ ft.

The cost of the statue is estimated at $250,000; the cost of the pedestal and the erection of the statue, $350,000. Total cost of the work completed and in place, $600,000.

The size of the statue is far greater than any other in the world, having a total height, with its pedestal, of 149 ft. 10 in. above the sea, while the celebrated Colossus of Rhodes was 105 ft., and that of Nero, by Zenodore, about 118 ft. The difficulties in the execution of the work, and the great care and skill required in its erection, now nearly brought to a successful issue, can be readily understood even by those unacquainted with the details of such work.

The design and modeling for the statue itself was a work of vast labor. A preliminary study model, seven feet high, was executed by the sculptor, Auguste Frederic Bartholdi, and, having been approved by him, another, four times the size, was prepared. This was very carefully studied and remodeled, and was then divided into a great number of sections, each of which was marked with a distinguishing figure or number.

The exact form of the statue was now settled, and the sculptor proceeded to construct models of the moulds upon which the copper casing or envelope which forms the entire exterior of the statue should be shaped.

Each section was then very carefully enlarged again to four times the size, and rough frames were prepared and lathed all over to conform somewhat to the shape of the section. Upon these the sculptor prepared his plastered models, as shown in the engraving, which represents Mr. Bartholdi at work upon them.

This was done in a specially constructed workshop of Messrs. Gaget, Gauthier & Co., in Paris, the enlargement being carried out with geometrical precision by means of a number of wires and leads attached to the pieces, from which measurements were taken off with compasses, each section requiring some 9,000 separate measurements.

As the models were completed, carpenters were employed to make wooden models from them by means of planks crossed or laid close together and cut out in silhouettes. Upon these the copper was moulded by blows from mallets, assisted by levers; the fine finishing touches being given with small hammers and rammers. Sheets of lead pressed upon the model were employed to assist in the moulding of the copper.

Iron braces, to be used in uniting the plates of copper with the main supporting truss, were next forged and fitted to the form of copper, and the sections were then carried to the yard and fixed in their places on the frame.

The form of the supporting frame can be seen by referring to Figs. 2 and 3. It consists of four massive angle iron corner posts, united by horizontal angle pieces, dividing it into panels, which are strengthened by steel struts and braces, arranged diagonally, and side extensions are provided to approach more closely to the contour of the figure. The smaller frames supporting the head and the extended arm of the figure are of lighter construction than the main frame, but are arranged on the same plan. The whole of this trusswork was designed and executed by the consulting engineer, M. Eiffel. On completion of the figure, it was taken to pieces and shipped to America.

During the time the statue was in course of erection in Paris, a suitable pedestal was being erected here for its reception. Bedloe's Island was chosen as being the most central one available, and, although small, it is yet of ample size for the purpose.

The successful appearance of the work depended to a great extent upon the size and design of the pedestal. It was essential that while presenting the appearance of solidity, strength, and magnitude necessary to accord with the great height of the statue, it should not be so large and prominent as to detract in any way from the beauties of the figure.

The pedestal, as erected from the designs of Mr. Richard M. Hunt, the architect, is very successful in point of size and general appearance, as can be seen from our engraving showing the final appearance of the statue.

The foundation is a solid concrete base, 52 feet 10 inches high, 90 feet square at the bottom and 65 feet at the top, and is built upon a soil composed of stiff clay, gravel, and bowlders, to the terrace level, where the pedestal proper begins. This is probably the largest solid block of concrete in the world. Through the center is a well hole or shaft 10 feet square, with four arched spaces at the bottom leading therefrom.

Surrounding the concrete base is turned a concrete arch about 3 feet 6 inches thick, and having a chord span of 49 feet. This supports the grass mould covered over it to form a slope around the base, and it also supports the four flights of steps leading to the terrace.

Upon the concrete base is erected the pedestal proper, which is constructed of granite, with a concrete backing. The vertical section, Fig. 3, shows the construction. The top of the pedestal is shown in the plan marked A, and is 43 feet 6 inches square, the corners being cut off to form an octagon. The balcony at top is 3 feet 7 inches wide in the clear. The loggia, shown at B in the engraving, is 26 feet 7 inches high, the opening being 27 feet 11 inches wide and 13 feet deep in the clear. The columns are 3 feet 4 inches wide and are 6 feet apart. Around the base of the pedestal is the terrace, 15 feet 6 inches wide, and the staircases leading to it have a clear width of 10 feet. Shields bearing the coat of arms of the several States are arranged around the base.

The work of connecting and holding the statue by its framework to the pedestal was accomplished in the following manner, from the designs of General Charles P. Stone, Chief Engineer, under whose superintendence the work was carried out. (See illustrations, Fig. 3.) Across the top of the pedestal are placed six plate girders, arranged in two sets of three each, and immediately beneath these are two similar sets crossing at right angles at points exactly under the vertical corner posts

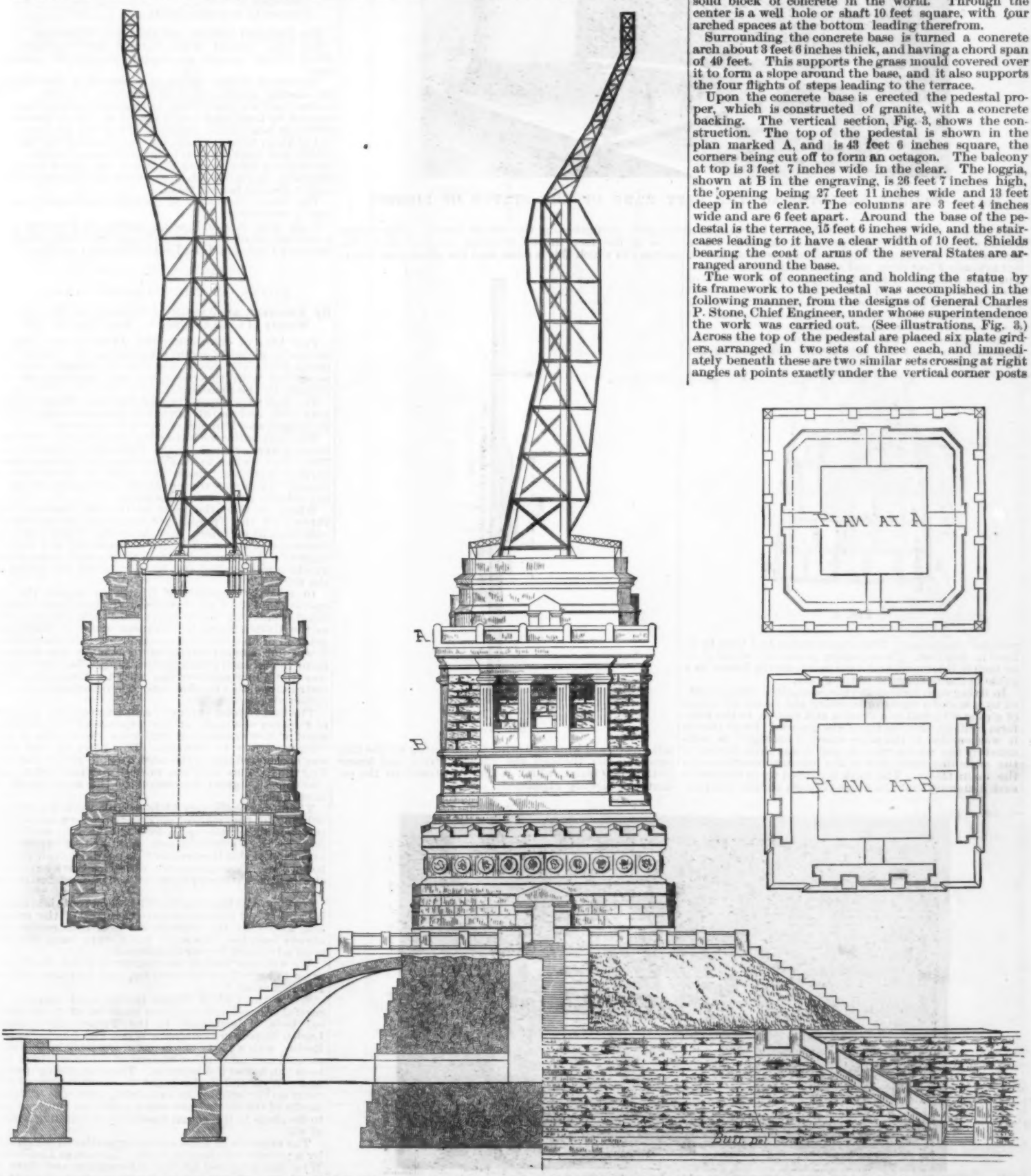


FIG. 3.—THE STATUE OF LIBERTY.—ELEVATION, PLANS, AND SECTIONS OF PEDESTAL, SHOWING METHOD OF ANCHORING THE STATUE.

of the supporting frame, to which they are united by three bolts, 5⅛ inches in diameter. The plate girders are 34 feet long and extending across the well-hole or shaft, which is 26 feet 6 inches square, have a bearing at each end of 3 feet 9 inches. The girders are 4 feet deep and are built of ⅝ inch web plate and 4 inches by 5 inches by ⅝ inches angle iron.

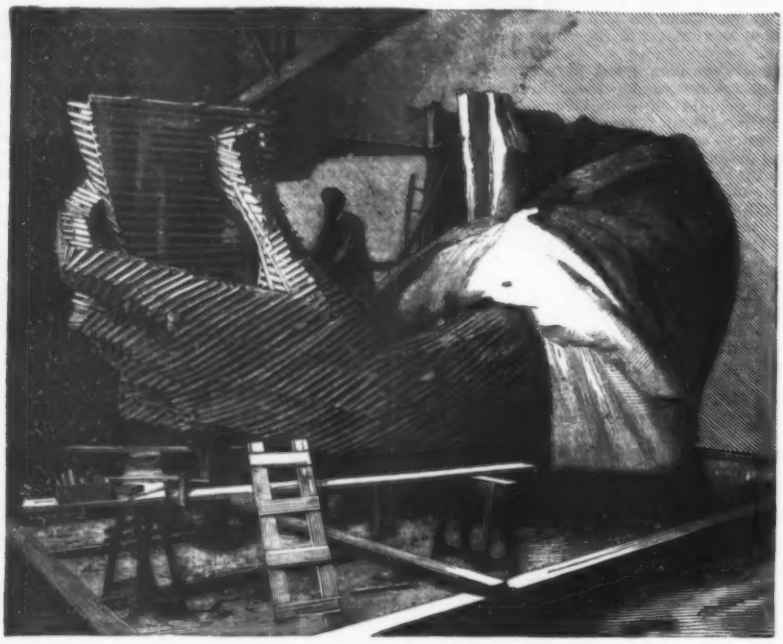


FIG. 4.—WOODEN SKELETON OF THE LEFT HAND OF THE STATUE OF LIBERTY.

At a depth of a little over 60 feet below, is arranged a second and similar system of girders, 41 feet long. These girders are of the same thickness of iron as those above, but are only 3 feet deep, and are arranged two in a set. The two systems of girders are joined by four sets of eye bars, consisting each of four bars 4 inches wide and 1¼ inch thick, placed close to the side of the walls of the shaft, and are prolonged to join the main frame at the top of the first or second panels.

The supporting frame having been erected upon the pedestal, presented the appearance indicated in the

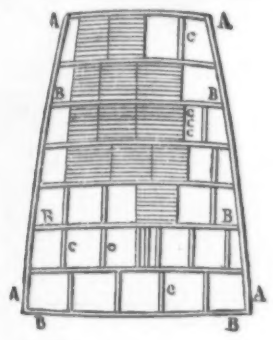


FIG. 6.

annexed engraving. The copper casing had then to be fixed in position. These copper plates are about $\frac{1}{16}$ of an inch in thickness, and were marked with figures as a guide in the re-erection of the figure.

In fixing each section the piece required was protected by a wooden frame or covering and raised by means of a rope attached to a derrick and engine, to the platform built around the top of the pedestal. From thence it was carried to the place where it belonged as indicated by the marks upon it, and it was then riveted to the adjoining plate and to the braces connecting it to the main frame. The work is carried up in courses in such a manner that the weight of each section is directly transmitted to the frame, being independent of the plates adjoining it.

The copper plates are rendered rigid by being stiffened with iron bars ¾ inch by 2 inches, bent to conform closely to the curves in the copper, to which they are fastened by copper bands whose ends are riveted to the casing, forming a close network of bracing, covering and strengthening the whole statue. The inside view of the face in the drawing annexed shows the manner in which this is done, and the effect is to transmit pressure of wind and other forces acting on the thin outer copper through the various struts and braces to the main frame, which is firmly fastened to the pedestal as already explained.

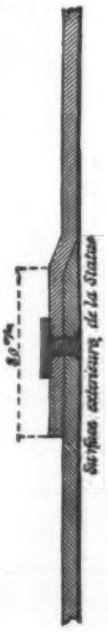


FIG. 7.

FIG. 5.—THE STATUE OF LIBERTY.—HAMMERING A PLATE OF COPPER INTO A PATTERN.

The riveting of the plates is of three kinds. Where the joint is to be concealed, the edges are brought together and covered on the under side by a strip of copper, through which pass two rows of rivets with their outer heads countersank. In other cases one edge overlaps the other and a single line of rivets pass through the overlapping edges, the outer one of which is hammered down where the location renders it necessary. A staircase is provided leading to the head, with steps up the outstretched arm.

The principal dimensions are as follows:

	Feet.	Inches.
From bottom of plinth to top of torch	151·41	
Heel to top of torch	111	
Height of head	13	6
Width of eye	2	4
Length of nose	3	0
Length of forefinger	7	11
Circumference of finger at second joint	4	9
From water level to top of pedestal	149	10
Water level to foot of pedestal	60	10
Foot of pedestal to top of same	89	
From high water to top of sea wall	10	
Top of sea wall to foot of fort wall	2	6
Foot of fort wall to gravel level, at parapet of fort	23	6
Parapet to foot of pedestal	24	

The head will hold 40, and the torch 15 persons.

The total weight of the statue is 440,920 pounds, of which 176,368 pounds are copper and 264,552 pounds iron.

The object of the statue as a beacon is effected by the electric lighting now in course of erection. The statue itself is to be brilliantly illuminated from base to summit by four large lamps placed in front of powerful reflectors behind the parapet. They will be arranged out of view, to throw light on every part of the figure, which will thus be visible on the darkest night. On the balcony surrounding the torch are placed at equal distances apart eight lamps of 6,000 candle power each, with reflectors behind them.

The whole structure in its final appearance is eminently satisfactory.

Long may it stand as an emblem of Freedom and a monument of the good will and friendship existing between France and the United States of America!

NOTES ON THE PANAMA CANAL.

By Charles D. Jameson, Member of the Boston Society of Civil Engineers. Read May 19, 1886.

The idea of connecting the Atlantic and Pacific oceans by means of a ship canal across the isthmus between North and South America was almost contemporaneous with the discovery and conquest of the country by the Spaniards.

The first paper upon that subject was written in the year 1550, and in this paper the relative values of the Nicaragua and Panama routes were discussed.

The next notice we have of the idea was in 1779, and surveys were ordered by the Spanish Government in 1780. But owing to complications in Europe, these surveys were not made, and none of these earlier Spanish projects ever advanced far enough to have any reliable surveys or plans made.

When, in 1825, the most of Central America had thrown off the Spanish yoke, and had become small, independent republics, they, knowing so well the configuration of the coast and the feasibility and advantages of a ship canal, did all in their power to have the question well studied and brought before the notice of the world.

In 1825 the republic of Nicaragua asked the cooperation of the United States in the building of a ship canal connecting the Atlantic and Pacific oceans. But as the United States Government could at that time get hold of no reliable data connected with the subject, it was not deemed advisable to commit the Government to any such grand undertaking. The only result was that a new minister was sent to Nicaragua, with instructions to examine into the question fully and collect all possible data.

The first regular survey of a line across the Isthmus of Panama was made at the expense of the Government of New Grenada in 1828, from the mouth of the Chagres River to Panama. This place at that time was considered one of the most feasible places for cutting the isthmus, as it was one of the narrowest, and also there is a great depression in the main chain of mountains.

There was really very little reliable work done on the isthmus in the way of any surveys for a canal until 1870, and from then up to 1880 all the best work was done by the United States Government. The principal attention of this Government has always been turned toward the Nicaragua route, although there have been eleven different routes surveyed and plans and estimates made.

Owing to the fact that the Nicaragua route is in a more inhabited and healthy climate than any of the others, and also that the estimated cost of construction has always been less, this route has always been the one most advocated by our Government.

We will now look at the manner in which the French came to have the concession for, and the control of, the Panama canal.

While the United States Government was having careful surveys and estimates made of all these different lines, a lieutenant in the French navy named Lucien Napoleon Bonaparte Wyse, and Lieut. Armand Reclus, with a party of about twenty men, in 1876 commenced an examination of some of the lines which had been run across the isthmus. These exploring parties under Wyse and Reclus spent the better part of two years on the isthmus in examining into the different merits of the many lines which had been run, and also to decide as to the actual feasibility of building a canal at all.

The expenses of these exploring parties were defrayed by a private company in Paris. As soon as Lieutenant Wyse had procured all the information and data he required, or at any rate had used up all the time at his disposal, he pushed on at once to Bogota, the capital

of the United States of Colombia, and on March 28, 1878, got his concession signed by the Government.

By the terms of this concession he was granted the exclusive privilege of constructing a ship canal from Colon to Panama, for a period of ninety-nine years; the canal to be finished in 12 years after the organization of the company; and if any unforeseen obstacles are encountered, the limit of time for construction will be extended six years more. There can be no doubt but that the canal company have a right to this additional six years, as most of the obstacles which they have encountered appear to have been entirely unforeseen.

Lieutenant Wyse then went at once to New York, to see what arrangements could be made with the Panama railroad, as it was then evident that the best line between Colon and Panama must run near the line of the railway, or at least within their right of way, and that the co-operation of the railway company would be all-important to the construction of the canal.

Having made his arrangements in New York, he sailed at once for France. Now, this company of which Wyse was the head had a concession and all the rights necessary for the construction of an interoceanic canal across the Isthmus of Panama; and the only, and by far the most important, thing which they lacked was the necessary amount of money.

In order to form a company and raise the immense amount of money necessary for the undertaking, it needed, as the head and front of the enterprise, a man the simple name of whom could so inspire and rouse the people that, without knowing much more about the enterprise than the one fact that this man was at the head of it, would give them unbounded confidence

in its success and the enterprise unlimited credit. The only man who could fill these requirements was Ferdinand de Lesseps, who, with his fame founded upon the construction and success of the Suez Canal, could raise money to any amount for any enterprise to which he lent his name.

Le Comte de Lesseps was induced to become the head of the Wyse-Reclus canal project, and a scientific congress of all nations was called at Paris to decide as to which of the many lines run across the isthmus was the best. The decision of the congress was in favor of a sea level canal from Colon to Panama. This decision was rather a foregone conclusion, from the fact that the Colon and Panama route was the only one of which Wyse held the concession and of which De Lesseps was the head. Unless one has been in France, and particularly in Paris, one can form no idea of the amount of influence and blind enthusiasm the mere name and reputation of one man can arouse. De Lesseps made a success of the Suez Canal in the face of the strongest opposition, and to the ordinary French people he is little less than a god. The majority of them are satisfied with the fact that he says the Panama Canal will be a success, and up to the present time he has merely had to ask for money to get all and more than he asked for. In June of 1884, when he called for 80 millions, the morning when the books were opened to receive subscriptions, the streets were packed for blocks with people who took their luncheon and crowded and pushed all day to get a chance to let *him* have all their savings. The money which has thus far been spent upon the Panama Canal has not come from rich bankers and capitalists, but in small lots out of the pockets of women and orphans and the middle class of French people, who seem willing to pour into the capacious pockets of De Lesseps their last cent, and take his word for it that at some time in the future they will reap their reward. Perhaps they may. Where the remainder of the money needed to finish the Panama Canal is to come from is a query.

We will now leave Le Comte de Lesseps and his poor people in France and go to the Isthmus of Panama. The administration of the Canal Company upon the Isthmus is as follows: Director-General, Assistant Director-General, Chief Secretary, Chief Engineer, and a great number of other chiefs up to about 700. In fact, nine out of ten of the employes of the Canal Company are chiefs of something, and a man must indeed be down pretty low not to be able to write chief after his name. During the five years of construction upon the Isthmus there have been eight different administrations, no one of them lasting two years. Of course, this has been a source of great loss to the Canal Company, which can hardly be exaggerated.

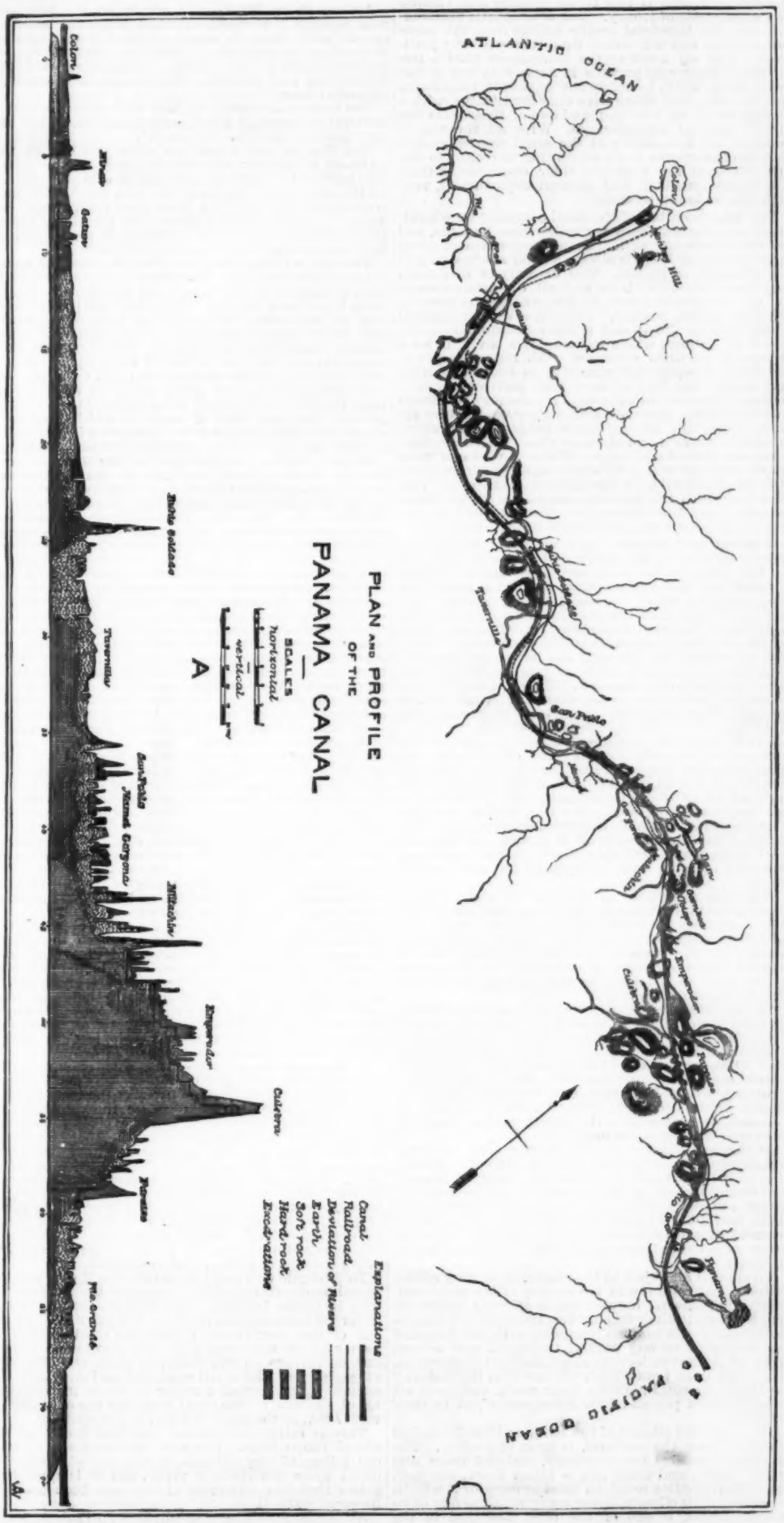
The Panama Canal is to be a sea level canal from Colon on the Atlantic side to the mouth of the Rio Grande, on the Pacific side near Panama. The total length will be 74 kilometers, or about 45 miles. At the Pacific end there will be a tide-gate by which to control the excess of tide of the Pacific Ocean over that of the Atlantic. The difference between high and low tide in the Atlantic at Colon is only about 12 inches, while in the Pacific it is 20 or more feet.

At the Panama end there will be a basin 1,600 meters long and 110 meters wide. At Traverulla, at about the center of the canal, there will be a large basin about 5 kilometers long, and at Colon there will be a basin well protected by a sea-wall—a basin 3 kilometers long and 1 kilometer wide.

The bottom of the canal will be 30 ft. below the water line, and will be from 100 to 200 ft. wide. The deepest cut upon the center line is at kil. 55 Culebra, where it is 330 ft. for a short distance. At this point the depth of cutting at the slope stakes runs up to 450 feet.

By means of the profile one can form some idea of the comparative quantities of each kind of material to be excavated. The whole line of the canal has been sounded to its full depth by means of the diamond drill, and the cores of the entire soundings extracted and classified.

The city of Colon (Aspinwall) is situated upon an island upon the Atlantic side of the Isthmus of Panama, and the whole of this island is owned and occupied by the Panama railway, who will not sell one foot of it. The city itself consists of only two streets running parallel to the water, and which, before the fire of March 31, 1885, were lined with stores, bars, and tenement houses.



There is no drainage of any description, and refuse of every kind is thrown into the streets, which, with the vacant lots, are gigantic cesspools. You hear a great deal about the deadly climate of the Isthmus, and beyond a doubt it is unhealthy. But if the people here in Boston lived in so much filth and drank as much brandy, the death-rate would be nearly as great.

When the canal company wished to build their offices, store-houses, and dwelling-houses at that end of the canal, there was no land available where they could build a line of wharf which would be accessible to vessels of all kinds. So to the south of the island they took a large swamp, which was usually under six feet of water, and filled it with broken stone and gravel to about six feet above high tide; on the top is put 18 inches of rotten coral to give it surface. This rotten coral packs down very firmly, and is entirely free from dirt and dust. This whole fill contains about 85 acres.

Upon one side of the fill there is nearly one mile of stone wharf, with about 25 feet of water. Upon this fill are built all the dwelling-houses, offices, store-houses, etc., of the canal company.

That part where the dwelling-houses are built is laid off well in streets, and is well drained. There are side-walks and cut stone gutters. All the buildings are built upon masonry pillars a few feet high, in order to allow the air to circulate freely under them.

The whole camp is in charge of a special police force, whose only duty is to keep it clean and orderly.

Owing to the fact that all the freighting is done by cars and locomotives, it is very seldom that the streets

of this encampment are desecrated by the presence of any beasts of burden, or that the streets are cut up by wagon wheels. Therefore, the camp can be and is kept most exquisitely neat and clean, and no expense is spared to accomplish this object.

Much of this care and expense, which is lavished not only upon the camp at Colon, but upon the camp of each section along the whole line of the canal, strikes the American who is new to the country and climate as a great waste of money. But after a little examination into the beneficial results arising from this same expense, any one will admit that it is perfectly justifiable. You all know by the newspapers what a tremendous death rate prevails in Aspinwall, but at the canal camp, which is merely one part of it, from June, 1884, to June, 1885, there were only four deaths, with a population of six hundred, and two of these were the direct result of intemperance. With all the sins of omission and commission of the canal company—and they are many—one must admit that in regard to the care taken of the health of their employes, in their commissary, sanitary, and medical departments, very little can be found lacking.

The large hospitals of the canal company were built, at an immense cost, at a few miles from Panama, and 200 feet above the sea. The position was most admirably chosen, as there is always a good sea breeze, and the drainage is perfect. The capacity of this main hospital is about 400 beds, and all the arrangements for the comfort and care of the invalids are made in the most perfect manner. There is a smaller hospital of 100 beds at Colon, and a fine sanitarium upon the island of Taboga, where the employes are sent for a change of air when necessary. All the employes of the canal company are admitted to these hospitals, and receive the best of care, food, and room, free of charge. The only thing needed is a doctor's certificate that he is sick. Any men working for contractors are admitted to the general wards for $1 per day, which includes everything; and those who wish it can have a private room for $1 extra. When the price of table board—and not very good board either—is from $50 to $100 per month all over the Isthmus, one can see that these hospitals are an immense expense to the canal company, and that they spare nothing which in any way tends toward the good health of their employes.

However well disposed one may feel toward the canal company, no one can deny that the management on the Isthmus has been very loose and very badly directed, and that a tremendous amount of money has been spent for which no result can be shown. The most noticeable thing about the employes of the canal (with one or two rare exceptions) is that none of them feel any interest in the success of the enterprise. Every man is working for himself, and seems to care very little what progress is made so long as he draws his salary regularly once a month. There is none of that holding a man down to his work, and either making him do it or getting some one in his place at once who will do it, that we see among the Americans.

Owing to the unhealthiness of the climate and the consequent uncertainty of life, the one idea on the Isthmus seems to be, get what you can, how you can, as quick as you can, and get out of the country. The main offices of the canal company are in Panama, in one large building which contains, during working hours, between four and five hundred employes. The salary of the director-general is $100,000 per year and all his expenses, including house, horses, carriages, servants, etc.; in fact, everything he can possibly want.

With the exceptions of some six or eight persons holding the most important positions, and whose salaries range from $10,000 to $25,000 per year, the salaries paid by the canal company are not by any means high, considering the country and the prevailing rates of wages for the same class of services by the other companies, such as the Panama Railroad and the Pacific Mail Steamship Company.

The line of the canal is divided into sections of about six miles each. Each of these is in charge of an engineer. He has a first assistant, clerk, draughtsman, instrument men, time-keepers, store-keepers, doctors, etc. The salary of a chief of section is $200 or $250 per month and his board; assistant chiefs $150, and instrument men and draughtsmen, from $60 to $100 per month. A chief of section was allowed $2 per day for expenses, and below him about $1.50 per day, varying, of course, with circumstances.

At the headquarters of each section there are comfortable and airy houses, sufficient for the accommodation of all the employes above the rank of laborer, and large barracks for the laborers. All these section camps are well policed, have a capable doctor and a small hospital. These section hospitals are merely to be used in case of accident or in very mild cases; in other cases, the patient is sent at once to either Panama or Colon.

To make it an object to the employes to stay on the Isthmus and continue in the employ of the canal company, the following inducement is offered: When any one has been in their employ two consecutive years, he is entitled to six months' vacation, with full pay, and his fare paid to any part of the world and return. Very few, however, have been entitled to this vacation, and it has been found that, of those few, the majority preferred to continue with their work, and have six months' extra pay and $200 for expenses put to their credit.

Of course, the climate of the Isthmus, like all tropical climates near the sea-level, is most unhealthy. The prevalent diseases are dysentery, malarial fever, and yellow fever; and when one is taken down, the most powerful remedies must be used at once, or it will be too late. This climate, doing away with the fact of its unhealthiness, is one of the most beautiful in the world, but not the most invigorating. The nights are all cool enough to sleep well, and in the shade the heat is never oppressive in the day-time.

We will now take a look at the class of men who are doing all this work on the Isthmus.

Most of the higher positions are filled by Frenchmen, but the chief secretary, who is one of the hardest and best workers on the Isthmus, is an Englishman, Col. Chamberlain, of the English army.

The chiefs of sections are all French, and the clerks, under-secretaries, store-keepers, etc., are mostly Jamaica or Martinique negroes who have a fair common school education.

The laborers are in about the following proportions:

Greeks and Italians	0·10
English, Americans, and Swedes	0·06
Germans	0·04
Colombians	0·20
Jamaica and Martinique negroes	0·60
	1·00

Among these, the Greeks are by far the best and most intelligent workers, but much care must be taken not to work them in mixed gangs, but in gangs by themselves, as they are a vindictive, quarrelsome set, and very ready to use a knife. Being much addicted to drinking and gambling, they cannot be in any way depended upon.

The Swedes are about the best workers where only a moderate amount of intelligence is needed. They are very faithful, but also very stupid.

The English and Americans whom one sees on the Isthmus as laborers are the very scum of the earth. The most of them are runaway sailors who are tempted by the larger pay. As a general rule, the English and Americans of the laboring class upon the Isthmus are divided into two classes: either they are killing themselves with drink, and are therefore of no use, or else they are such fools as to be absolutely useless.

The native Colombians are of Indian blood, or Spanish and Indian mixed. They are a straight, well-built race, but owing to the climate and the very little need there is for work in order to live, they are a lazy, indolent set, who make the women do most of the work, and whose only desire seems to be plenty of sleep, bananas, cigarettes, and brandy. Consequently, they cannot in any way be depended upon by either the canal company or the contractors; and until the last year they have been so much taken up with revolutions that they have cared little whether they worked or not. The only kind of work for which they have shown any adaptability is the clearing of the "right of way," and most of this work has been done by them.

In this question of the supply of the manual labor needed, which, without doubt, is the gravest one the canal company have to face, the Jamaica negro seems to be the only answer, so far, that has any degree of stability to it. They form the main body of the laborers upon the Isthmus, not because they are even as good workers as many other nationalities, but because there are more of them. They are mostly imported directly from the islands at the rate of about 1,000 per month under contract for two months at $1.50 per day.

There are no Chinese employed as laborers on the canal, but at every encampment you will find them as small merchants, and in the city of Panama there are several large mercantile Chinese houses. During the construction of the Panama railway, and once since, that company and the Pacific Mail Steamship Company have imported large quantities of Chinese as stevedores and laborers, but each time they have been a failure, and the companies have had to fall back upon Jamaica negroes. The laborers work from 7 to 11 A.M. and from 2 to 6 P.M.

The clerks and office men work from 8 to 11 A.M. and from 2 to 5 P.M. No employe of the canal company ever by any accident overruns these hours. There is no night work done, and no Sunday work.

Most of the actual work which has been done upon the line of the canal has been done by contract, and in all of these contracts, with the exception of two, of which I will speak later, the tools and all the necessary machinery were furnished by the canal company. The contractor is obliged to give bonds for only 10 per cent. of the amount of his contract, and to pay 7 per cent. of the cost of the tools for their use.

During the last three years the great object of the administration on the Isthmus has been to make a showing in the amount of material excavated, and therefore any one who could give any bond at all, and would agree to commence work at once and push it, could make his own conditions with the canal company. For this reason all the large contracts which had been made up to one year ago were all in favor of the contractor, and any of them who lost any money on them must indeed have been stupid.

In these contracts, where the canal company furnished all the tools and machinery, any delay caused the contractor by the non-delivery of the tools on time is so much more time allowed to the contractor in which to finish his work; and any expense caused the contractor by the non-delivery of the tools, etc., such as large gangs of men, locomotives, and excavators standing idle, must all be paid for by the canal company. The service of the store-houses being organized in nothing but an immense amount of "red tape," a judicious contractor usually had a monthly estimate of damages due him two or three times as large as the amount due him for actual work done. In this way contracts could be taken at a very low figure, and still prove a source of profit to the contractor.

To illustrate this point more fully, I will give you the actual figures on one of the largest contracts which has been let on the Isthmus. The contract price per cubic meter for material excavated we will call 3 cts. At the end of one year's work, taking the total amount of money which had been paid this firm for work done and demurrage on the machines when standing idle at expense of the canal company, and dividing this amount by the actual number of cubic meters excavated, the cost to the canal company per cubic meter was 17 cts., in the place of 3 cts., as per contract.

This is rather an extreme case, but those are the actual proportions. You can, therefore, see at once the fallacy of any estimate of the cost of completion based upon the contract price-, and it is upon these prices that the estimates of cost have been based by the canal authorities.

All the large contracts are divided into sub-contracts where possible. No contractor, when it can possibly be avoided, ever works any men by the day, but all by task work. But the large gangs of laborers who work directly for the canal company are working by the day. That is, putting in so many hours per day on the work for which they are paid.

Common labor receives from $1.50 to $3 per day, and skilled labor, as machinists and boiler makers, $5 to $10 per day.

All the laborers receive their pay every two weeks. Office men receive theirs once a month, and contractors receive theirs once a month or as per terms of their contract.

The main store-houses of the canal are at Colon, but at each section camp there is a large one well stocked, and also some large ones in Panama. These store-houses are packed with everything one can imagine, and most of the articles in the most ridiculous quantities. For example, they unloaded and packed away in Colon, in one place at the same time, 600 anchors all of the same size and make.

Each of these store-houses is in charge of a chief and a number of assistants, who report to the chief-general of the store-houses and material. But if you wish for anything in a hurry, the only way to get it is to hunt round till you find which store-house it is in, and then, getting an order from the director-general of the canal for it, go and get it yourself.

MACHINERY.

For all the train work which is done on the main line of the Panama Railroad, American locomotives and American or English drivers are used entirely, but for all canal work in their own yards and cuttings, a small French or Belgian locomotive is used.

The dump cars used in the excavation are of English, American and French make. In opening all the works, small hand cars are used until there is a sufficient face on the work to admit the use of the steam excavator or the steam shovel.

The steam shovel used the most and the one which gives the best satisfaction is the Osgood & McNaughton, Albany, N. Y.

One of the best working excavators used is of French make. It consists of an endless chain of buckets, which works either at right angles to the track upon which the excavator stands or in the same direction. The ladder around which the buckets revolve can be raised or lowered at the bottom so as to feed the buckets, and the excavated material is dumped into a hopper about 20 feet high, from which it falls into a dump car which runs upon a parallel track. The motive power is connected to the buckets by means of a flat chain running over a toothed wheel.

The company have on hand pumps of almost every description and size, and miles of large, heavy piping, which they propose to use in the following manner. Of course, one of the gravest questions to be answered in connection with the construction of the canal is, What is the cheapest and best way to dispose of the material which will come out of the large cuts in the interior? There is very little chance for spoil banks without crossing the mountains into the next valley, and the length of haul stretching out into miles. Now the design, and to a certain extent the practice, is to dump all this material into large tanks placed in convenient positions and partly filled with water. These tanks contain agitators which reduce the whole to a semi-fluid state, and then the large force pumps force it all through these miles of pipes to the most convenient dumping ground. At every section camp where any work of construction is going on, there is a machine shop of greater or less extent. The main machine shops are at Gorgona, and are well fitted up in every detail. One reads a great deal in American newspapers about the immense quantities of machinery which have been allowed to rust away to ruin. This most certainly is an exaggeration. Of course, some machinery imported has been ruined by rust, but only a very small per cent. The rest of it is all taken good care of, and kept in working condition.

FLOATING MATERIAL.

This includes in Colon a rowboat with an awning and from one to eight oarsmen for each chief, assistant chief, head clerk, clerk, etc. As a man's position is, so is the number of his boatmen.

There are two small steam launches and eighteen towboats, all of them very small except six. All these boats are of metal, and English build. There are six large steam hopper barges (clapet), also English build. These barges and towboats are mostly manned by Greeks, who are the best sailors and pilots to be found in that part of the world.

All the dredges used on the Atlantic end of the canal work a number of buckets upon an endless chain. There are three classes of these dredges:

1st. Small French dredge.
2d. English marine dredge.
3d. American dredge, Hercules type.

The French dredge is a small dredge, with the bucket ladder projecting in front so that it can dig its way into banks, and thus float itself. One drawback to it is that it has to be held to its work and moved bodily from side to side and ahead by means of chains and anchors run out ahead and on each side. The buckets empty into a hopper 25 feet from the water, and the material falls at once into a scow moored alongside for the purpose, and which, when full, must be removed by a towboat and another put in its place. The capacity of these dredges is about 800 cubic meters in good material per day. The English marine dredge is built all of steel, and can dig 40 feet deep. They cost the canal company $200,000 each. They have only two of them, one at Colon and one at Panama. They both came from England under steam alone.

They can only be used in deepening channels, etc., as they only work under themselves, and must always have enough water to float them. They also discharge all the dredged material into scows or clapets. The power in both the marine dredge and the small French dredge is carried from the main engine to the shaft, which works the buckets by means of a flat chain running over toothed wheels.

The capacity of the marine dredge is about 1,000 cubic meters per day.

The American dredges are built and owned by the "American Contracting and Dredging Company," of New York, and I will here say that this company and the Franco-American Trading Company, which as yet has done no work to speak of, are the only contractors on the Isthmus who furnish their own machines, and also that up to date the American Contracting and Dredging Company are the only contractors who have made any headway in their work, or have complied with their contract as to time. At the rate at which they are now working, there is no doubt but that all their contract will be finished well within the required time.

The main differences between the American dredges and those already named is: 1st. Their immense size, the tower upon them being 75 feet high. They were built expressly for the Panama Canal, and dig 50 meters

wide by 10 meters deep. 2d. They possess the following great advantages:

All the material which they dredge is discharged at once upon the bank through a pipe 36 inches diameter and 150 feet long, and thus they do away with the use of all scows and towboats. In the last dredge built by this company, the New York, there is a discharge upon each side of the tower 170 feet long. There is enough water forced through these discharge pipes to force all the material dredged through them at a velocity of 500 feet per second.

The second great advantage which these dredges have is the manner in which they are made to walk themselves right up to their work, and thus do away with the anchors and chains in front and to each side.

The measurements of the work done by these dredges are taken at the end of each completed cut by an engineer of the canal company who lives on the dredge. These measurements are signed in duplicate each 12 hours by the canal engineer and the captain of the dredge, also a report of every stoppage which has been made by the dredge, and the causes. But very little of the dredged material runs back into the canal after having been deposited on the bank. Three miles of the canal was sounded after it had been dug over one year, and less than 18 inches had run back, and this with a continual passage of small towboats with lighters and barges in tow; and in regard to this I may say that the climate, which, by its heat, moisture, and unhealthiness, is the greatest enemy to the canal during its construction, becomes at once its best friend when it is constructed, because, owing to the rapid growth of vegetation, one year after the banks of the canal have been constructed, they will be so bound together by roots and vegetation that any danger there may have been from sliding or washing will be done away with entirely.

There are seven of these dredges now at work on the Isthmus, and the number of cubic meters excavated by them all during the month of January last was 728,000, or 104,000 cubic meters per dredge, which is the largest amount of work ever done in the same time by any machine. The total number of cubic meters excavated by this company up to January 31 is 5,200,000 cubic meters, or more than one-third the whole amount of work done on the Isthmus. In distance they have excavated 11 kilometers, or 6·6 miles, of the main line of the canal.

The "floating disembarker," which is used for the unloading of scows and barges which have been filled by dredges when the material is needed for embankments, consists of two large pontoons placed side by side, with enough space between them for the entrance of one of these dump scows. Upon each of these pontoons is a tower about 30 ft. high, connected at the top by a stiff truss. From the center of this truss is suspended a ladder around which the buckets revolve. The loaded scow is hauled in between the pontoons, the buckets lowered and set to work. The dredged material is discharged in the required place through a long discharge pipe.

There is one large floating derrick with a capacity of 60 tons.

The Franco-American Trading Company have a large contract for dredging upon the Pacific side in the valley of the Rio Grande; but thus far they have done no work to speak of.

The dredge used by this company is the single dipper dredge, built by the Pound Manufacturing Company, Lockport, N. Y., and in the manner in which it has to be used on the Rio Grande it is not a success.

The dredged material is dumped from the dipper into a box suspended from a derrick upon a car, which runs along the side of the canal. When the box is filled, it is swung away from the canal and emptied. The process is very slow, and, owing to the marshy ground, it is almost impossible to so lay the track upon which the derrick car runs as to give it sufficient stability.

Owing to the lack of water, the dredges can only be worked during high tide, and therefore have hardly dug out twice their own length yet, and the question of running their derrick car any distance yet has assumed no importance.

This company owns its machines and imports them in sections, to be erected on the spot. These are some of the principal pieces of machinery which are at work on the Isthmus, but without having been over the line of the canal and seen their storehouses, one can form no idea of the immense amount of material of all kinds which they have on hand. In fact, the whole 45 miles of the canal is nothing but one vast storehouse.

CHAGRES RIVER.

The Chagres River, of course, is the obstacle to the construction of the canal which requires the greatest amount of study to be overcome successfully. It crosses the line of the canal twenty-seven times, and in its upper part is from 100 to 150 feet above it. The first idea was to use the bed of this river, in part, as a part of the canal; but upon a very slight examination it was found that, owing to the immense amount of water which sometimes fell in a few hours, and the extreme rapidity with which it is emptied into the river, there was no way by which it could be controlled so as to be used as part of the canal; and thus what was at first looked upon as one of the strongest arguments in favor of the Panama route has since developed into one of the gravest obstacles.

In June, 1883, the Chagres at San Pablo rose 44 feet in four hours, and swept away most of the bridges of the Panama Railway.

The plan which was finally adopted, and is being now put in practice, for the control of both the River Chagres and the Rio Grande on the Pacific slope, is to so change the course of these rivers that in the place of crossing the canal they are carried down on each side of it in special canals where necessary, and the canal proper protected by large masonry walls on each side wherever these deviation canals approach within a dangerous distance.

Then the Chagres is to be further controlled as follows:

A short distance above Matachin, at the junction of the Chagres and the Rio Obispo, the Chagres turns sharply to the east, and passes between the Santa Cruz and Obispo mountains. It is between these mountains that a large dam is to be built by which to control the Chagres. This dam will be about three-quarters of a mile long and 150 feet high, with a base of 1,300 feet. The exterior slope will be four to one of broken rock, well reveted by heavy masonry.

Through the mountain Azul to the left of Santa Cruz will be cut a tunnel 600 meters long and 7 meters in diameter, through which will pass the waters of the Chagres. This dam will be built of the material taken from the large cuttings of Obispo and Emperador.

By means of this dam and tunnel, the flow of the Chagres can be regulated, and in times of flood any surplus water can be held back.

In one way the Chagres has been of some advantage to the construction of the canal. It is navigable for about 20 miles from its mouth, and thus the dredges can be taken up the river and started to work on the line of the canal at all the points where the river crosses the canal within this 20 miles, thus giving a great number of points where work can be carried on.

AMOUNT OF WORK DONE.

The total number of cubic meters of excavation in the canal proper is 122,000,000, and up to January 31 the total amount excavated was 15,000,000 cubic meters, leaving a balance of 107,000,000 cubic meters yet to be excavated in the line of the canal proper, and also all the extra excavation needed to change the course of the Chages and Rio Grande, and also the improvements in the harbor at Colon.

APPROXIMATE STATEMENT OF THE MONEY WHICH HAS BEEN SPENT.

Excavation 15 millimeters	$30,000,000
Houses, lands, clearing, etc	5,000,000
Machinery, material, etc	36,000,000
Administration in Paris and the Isthmus, expenses of organization, etc., etc	29,000,000
Cash on hand	7,000,000
Total	$107,000,000

To raise the amount of money, the liabilities of the company are $150,000,000, which at four per cent. equals $6,000,000 annual interest, which the canal company now has to pay.

In the above statement of the amount of money which has been spent, no mention has been made of the $17,000,000 which was the price paid by the canal company for a controlling influence in the Panama Railway, as no one outside the interested parties knows in what manner this sum is to be paid. Although the price seems tremendous to pay for the control of a railway 47 miles long, still, when the importance of the railway to the canal is fully realized, one can see that it is about the best spent money and wisest operation of the canal company. Although the French have now the full control of this railway, they have shown the good sense to leave the management of it entirely in the hands of its former American managers.

Of course, any estimate of the cost of completing the Panama Canal must be purely conjectural. But we must remember that it will not be fair to base any of this estimate upon the actual cost of the work that has been done. Much money has been spent in forming the company and such expenses, much more in buying their working plant, which they have now, and much more has been spent in buying experience and paying for the most costly experiments, the results of which they now have and from which they can profit.

APPROXIMATE ESTIMATE OF THE COST OF FINISHING THE PANAMA CANAL IN EIGHT YEARS.

Excavation, 107,000,000 cubic meters, at $1.50	$160,500,000
Chagres River and harbor	40,000,000
Administration	3,000,000
Total	$203,500,000
Banking and interest, 8 years	80,000,000
Total	$283,500,000
Interest on 283·5 million at 4 per cent.	$11,340,000
Interest on money already raised	6,000,000
Annual interest	$17,340,000

Which will be due if canal is finished in eight years at above cost. When the canal is opened for ships, the company can only charge $3 per ton for saving them 7,000 miles in distance, and it would therefore take 5,780,000 tons yearly to pay the interest. The amount of tonnage which will pass through the canal has been variously estimated from 3 to 8 millions.

Any estimate as to the amount of business which will be done by the Panama Canal when it is finished must be purely conjectural.

The first year the Suez Canal was in operation, its revenue from tolls was $900,000, in ten years its revenues were $7,500,000, and now they are $12,000,000 annually.

There are no insurmountable obstacles in the way of the completion of the Panama Canal in a few years The only question is money, and certainly as long as De Lesseps lives there will be no lack of that.

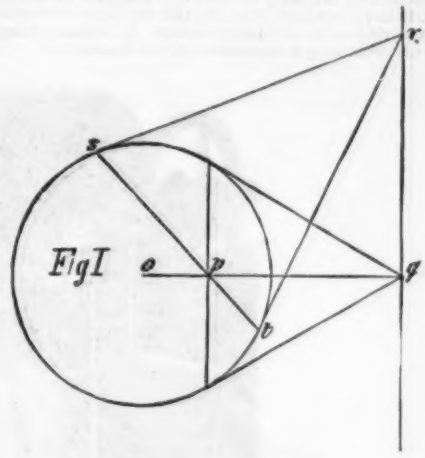
The management on the Isthmus has been loose and disjointed, but it is improving rapidly now. Undoubtedly money has been wasted, but no greater percentage than in other large enterprises. The work is being pushed in every direction. Contractors are being held to their contracts, and although no one can state the time when the canal will be finished, still no one can advance any proof or reason why it cannot be finished within the next eight years.—*Jour. A. E. S.*

ELECTROLYTIC SEPARATION OF METALS.

FROM solutions containing salts of various metals the metals may be completely and successively separated in a state of purity by using currents of different strengths. The current first applied must be only sufficient to throw down the most readily precipitable metal, but not the next following. The more of this first metal is deposited the feebler becomes the current, and finally a galvanometer introduced into the circuit is no longer affected; a sign that now none of the metal precipitable by the existing electromotive power is present, but only such saline solutions as do not conduct the feeble current, and consequently are not decomposed. If the negative electrode is charged and the electromotive power increased, a second metal can be precipitated.—*M. Kilian.*

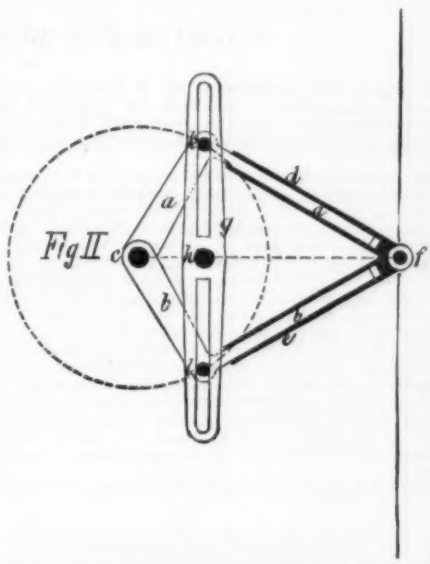
CONVERTING CIRCULAR INTO RECTILINEAR MOTION.

MECHANISM for converting circular into rectilinear motion is suggested by the following geometrical construction: Let a point p (Fig. I) be assumed anywhere within the circumference of a circle. Join the center



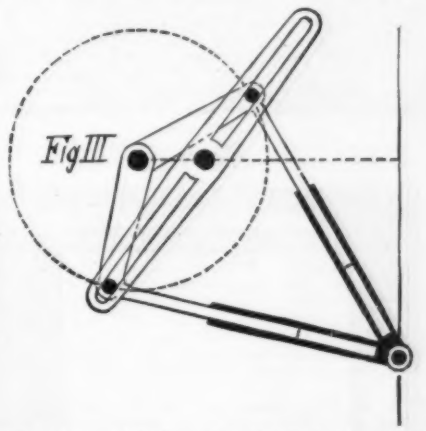
o with p by a straight line, and produce it beyond the circumference. On this line lay off a distance $o\,q$ so that the radius of the circle will be a mean proportional to $o\,p$ and $o\,q$. Through q draw $q\,r$ perpendicular to $o\,q$; $q\,r$, the polar of p, is the locus of the intersection of tangents to the circle drawn from the extremities of any chord passing through p. Thus, if we draw a chord $s\,p\,t$, and construct the tangents $s\,r$ and $t\,r$, they will intersect at r somewhere in the straight line $q\,r$.

The proposed mechanism is shown at Fig. II. Two



arms $a\,a$ and $b\,b$, on a common center c, free to move independently of each other, are fitted with sleeves d and e, which are jointed by the pin f. If now we add a slotted link g, which moves freely around the center h controlling the positions of the pins k and l, it will be seen that since the pins k, h, and l are always in the same straight line, the locus of the center of the pin f will, according to Fig. I, be a straight line.

Fig. III shows the mechanism in another position.



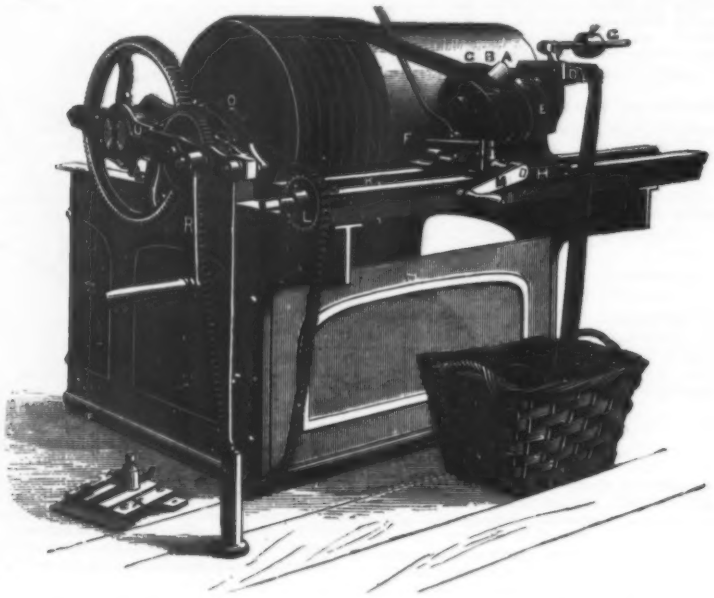
The above geometrical construction is clearly explained in Prof. Newcomb's "Analytic Geometry." See section: Synthetic Geometry of the Circle, p. 94.

FREDERIC R. HONEY,
Instructor in the Sheffield Scientific School.
New Haven, Conn., Sept. 20, 1886.

PROPIONIC ACID.—Propionic acid occurs in considerable proportions in the tars resulting from the destructive distillation of resin at the temperature of bright redness. Propionic acid boils at 141·5° to 142°. Its sp. gr. at 0° = 1·0089; at + 18° = 0·9904. It remains liquid if cooled to — 50°. It dissolves in all proportions in water, alcohol, ether, benzol, and petroleum essences.—*Ad. Renard.*

MACHINE FOR MOUNTING CARD SLIVERS.

NOWADAYS, cards are nearly always mounted upon carding machines in the form of ribbons or slivers. But in order to cover a large drum, doffer, or any other cylinder with card, it is necessary to have the aid of several men to pull and to hold with force the sliver that is slowly winding around it. Despite all precautions, it too often happens that the winding is defective, and the ribbon is not taut enough in certain places, thus necessitating a repetition of the operation.



MACHINE FOR MOUNTING CARD SLIVERS.

We owe to the kindness of Mr. F. Christy, of Lille, some data concerning a machine for mounting card slivers, constructed by the Dronsfield Brothers, of Oldham, and which does the work automatically and well.

The acompanying engraving represents the apparatus as arranged for mounting a card sliver upon a doffer shown at F. The sliver passes over a guide, D, which leads it to a barrel having three conical divisions, A, B, and C. The first of these, A, is 165 mm. in diameter, the second, B, 178 mm., and the third, C, 190 mm. The sliver first passes over the first division or cone, A, then over a curved piece, E, which directs it progressively to the cone, B, and afterward to C, which finally delivers it to the doffer, F.

The object of varying the diameter of the divisions of the barrel is to obtain an increasing tension of the card sliver. It will be remarked that the second division has a diameter larger than that of the first; consequently, it will require a greater length of sliver to cover it, and the traction upon the sliver will be stronger in consequence of the resistance of the division, A.

This same action occurs between the second and third division, but it is very progressive, and for this reason it is impossible to damage even the most delicate sliver. The entire tension is supported by the under side of the sliver, and is increased or diminished by varying the position of a weight along the lever, G, which acts upon the ribbon through pressure while it is passing in the guide, D.

The divisions of the barrel are covered with leather, in order to keep the sliver very taut, and the entire apparatus is mounted upon a carriage, H, so arranged that it can be moved along the table, K, through a screw that terminates in a cogwheel, L, which gears with another one, O, keyed to the shaft of the doffer. If need be, this forward motion of the barrel may be effected by means of a winch, M.

The doffer, F, is set in motion through the winch, R, which puts the large wheel of the cylinder in gear through a set of intermediate pinions. The figure shows how this is effected with sufficient clearness.

While the doffer is revolving once around its axis, the barrel, A, B, C, must be moved sideways exactly the width of the sliver to be wound, otherwise the spirals would run one over another.

As such width varies considerably, there is, in the transmission of the winch, R's, motion, a duplicate pinion which adjusts the mechanism according to the width.

With this machine the sliver is wound with mechanical precision, and with a uniform tension from the beginning to the end of the operation. Moreover, the operation can be performed by one man, where before it took four or five men.—*L'Industrie Textile.*

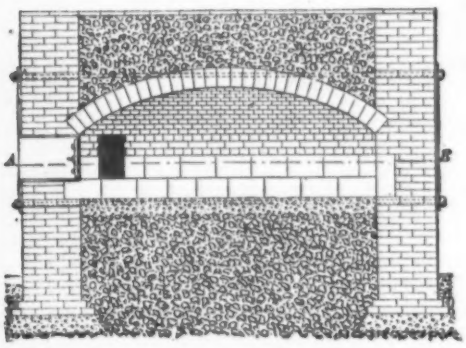
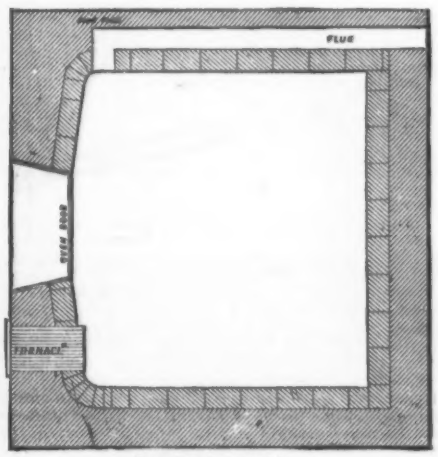


FIG. 1.



SECTION THROUGH AB.
FIG. 2.

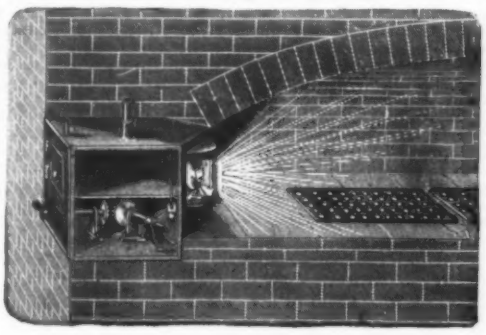


FIG. 4.

[Continued from SUPPLEMENT, No. 560, page 8945.]

AERATED BREAD MAKING.

By KILLINGWORTH HEDGES, M.Inst.C.E.

II.

THE working expenses of an aerated bread plant cannot easily be stated, as they depend very much on the situation of the bakery and the facility of obtaining materials, such as coal, sulphuric acid, and chalk, for the manufacture of the carbonic acid gas. At the bakery of the London company the cost of the gas was formerly 4d. per sack of flour, 8 lb. of acid being used in its manufacture; but by the improved process, which was introduced by the managing director, Major Childs, the cost has been greatly reduced, and now the expense of gas is 2d. per sack of flour. Five cubic feet of carbonic acid are required to aerate thirty-five gallons of water, which amount is required for every two sacks, or 560 lb., of flour. This is sufficient for four hundred portions of two pounds and a quarter each of dough, and for four hundred 2 lb. loaves of aerated bread. To the cost of the gas must be added that of the wine—whey or diluted ferment—which is made from malt and flour, eight gallons of which is added to every twenty-nine of water previous to its aeration. The capacity of the plant may be said to be limited only by the ovens, in that the mixing process should not occupy more than thirty minutes from the time the flour is taken from the sacks until it is placed as loaves in the oven. A plant similar to that before illustrated would have a capacity of 400 sacks per week, and would consist of one two-sack, one one-sack, and one half-sack mixers, each fitted with separate condensers, a 5 h. p. engine and boiler, a double set of gas pumps, a gas generator with acid feeder and trough, a gas bag reservoir, and a mash tub and refrigerator for Childs' improved process. To bake this quantity of bread, five ovens would be required, if employed only at night, but the output of the plant could be considerably increased, either by running the ovens during the day or by erecting additional ovens, so that the aerating plant could be worked continuously.

The ovens employed by the Aerated Bread Company in their Camden Town bakery are of a well known Scotch type, which, however, is not often adopted in the London district, owing to the cost of transporting the massive stones which form the "soles" or bottom of the oven. These stones are obtained from the quarry of Dunton Knoll, in Scotland, and are used on account of their heat-retaining quality, which gives great regularity of baking heat, with considerable economy of fuel. The amount of heat stored up can be imagined from the fact that it takes three weeks to heat an oven which has been allowed to lie idle for some time. The usual practice is to utilize the heat remaining after the bread is drawn for baking the smaller goods, such as cake and pastry; but, if necessary, the first baking heat can be retained for a considerable time, as the thick stone soles act as a reservoir. The accompanying illustrations (Figs. 1 and 2) show sectional elevation and plan of this oven. The fire is made in the side furnace, and the hot gases, after passing through the large space of the oven at a very low velocity—on account of which sufficient time is allowed for giving off heat—are led to the chimney by the flue on the opposite side. This oven is of course intermittent, as no bread can be baked while the fire is in. Many ovens, with continuous action, have been devised to overcome this drawback, and one of this improved type, by Messers. Bailey & Baker, was exhibited by Messrs. J. Baker & Sons at

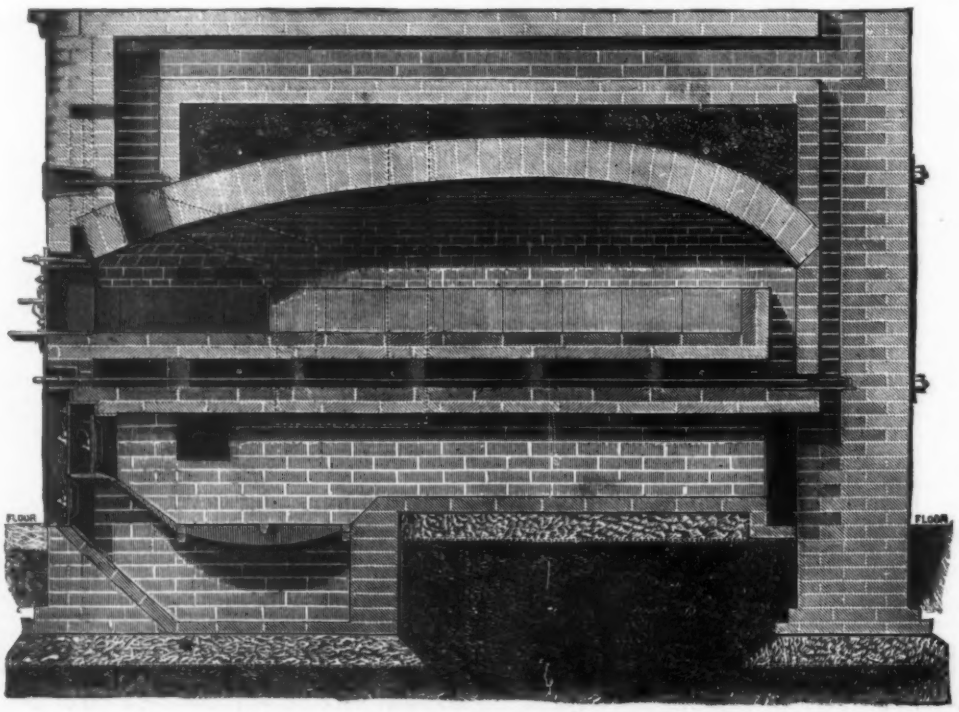


FIG. 3.

AERATED BREAD MAKING.

the Health Exhibition the year before last. Since then this oven has given great satisfaction in practical work. As will be seen from Fig. 3, which shows a sectional elevation of this oven, the object has been to bring about a similar result to that obtained with the Dunton Knoll stones. This is accomplished by arranging a hot air chamber above the furnace and between it and the oven floor, which is supported by brick columns, as shown. The draught through the flues is regulated by dampers, that leading to the chimney being above the oven door. This arrangement permits of a complete control of the internal heat, which may either be taken direct to the oven chamber or equalized and distributed to every portion by means of the air space. For fuel, coke is generally used, a siphon flue, shown by dotted lines, providing for the escape of fumes of sulphurous gas, without loss of heat. The consumption of coke is said to be from a half to one sack every twenty-four hours.

A new form of light is used for the interior of these ovens, which arrangement will be understood by referring to Fig. 4. The light is shown inside the oven by means of a gas lamp, which is so designed that, by turning a handle connected by bevel gearing with the lantern, the gas is automatically turned up, and by reversing this action, the light is turned down and the lantern withdrawn inside the fire door. The goods are examined through a small window in the oven door, which it is unnecessary to open, thus avoiding the loss of heat and steam, when the ordinary plan of a jointed gas bracket is used to examine the inside of the oven. The incandescent electric light is peculiarly well adapted for inspecting the interior of an oven, as it permits of the color of all baker's goods, pastry especially, being more easily judged than with gas light. This has been proved without a doubt by Messrs. Peek, Frean & Co., who were one of the first to put up a large electric light installation at their works, and find this method of illumination extremely useful, especially in their packing department, where biscuits of similar shade of color have to be packed together.

Contrasting the manufacture of aerated bread with the ordinary method, it is found to have the following advantages: First, cleanliness, in that the materials retain their original purity, and are untouched by the hand from the beginning to the end of the process. Secondly, a pure white bread can be produced without the use of alum or any foreign ingredient. Thirdly, rapidity of manufacture, the time required to prepare a batch of dough being less than thirty minutes, instead of eight or ten hours. Lastly, skilled manual labor is unnecessary, and the quantity of bread produced is regulated by the capacity of the plant; and, instead of a laborious night's work, the journeyman baker is not obliged to work more hours than is usual in other occupations, being at the same time relieved from a condition most injurious to his health, that of inhaling the fine flour dust in the process of kneading. —*Industries.*

THE "ROTARY" DRAWING FRAME.

FOR drawing slivers of long materials, and rendering them regular, drawing heads with screws and heckle bars are generally employed. As well known, these bars are made of iron, and are provided with combs with whose points the slivers engage. The extremities of the bars, which are properly shaped for that purpose, work between the threads of two parallel and horizontal screws, which, in revolving, give the bars a side motion. When the bars come opposite the drawing rollers, they fall between two other screws placed under the ones just mentioned, which bring them opposite the feeding roller, where they mount between the upper screws. Under each screw there are guides

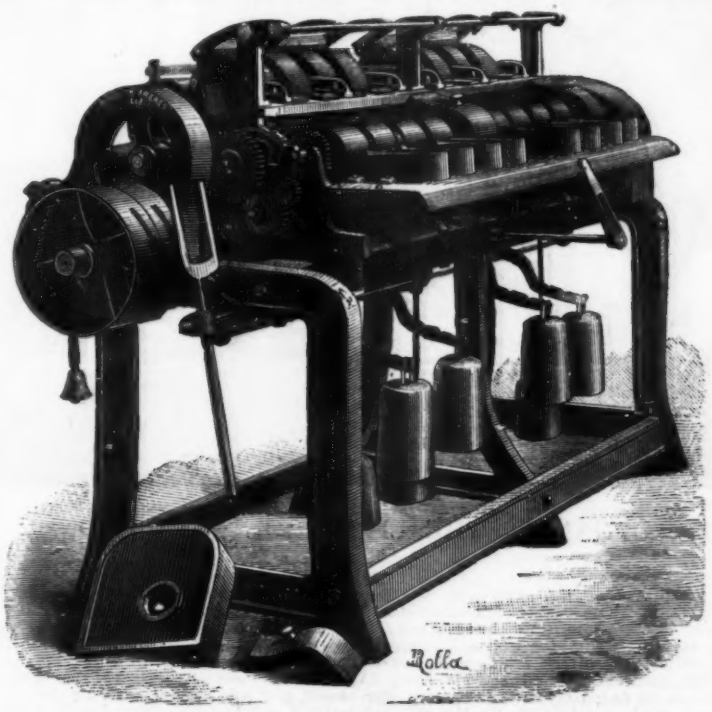


FIG. 1.—WINDSOR'S ROTARY DRAWING FRAME.

for the bars to slide upon. The upward and downward motions are effected by cams placed at the extremities of the screws, the mechanism of which it is not our purpose to describe in this place. We shall confine ourselves to the statement that in this system, which does the work perfectly enough, the machine can be run only at quite a limited velocity. If the velocity were too great, the bars, in their ascent, would often escape from the screws, and thus cause breakages. This system is therefore peculiarly adapted for the preparation of slivers designed for the production of very regular threads, and is likewise the only one that is applicable to very long staples.

Where it is a question of short fibers, such as those of flax, hemp, jute, etc., designed for the production of common threads, it is necessary to use machines that can be run with some speed, so as to increase the product and reduce the net cost. To this effect, different kinds of drawing frames, called "rotary," have been devised. We shall give a succinct description of two of the principal of these.

Drawing Frames with Urchins.—In this system, the screws and bars are replaced by a roller armed with points, and called an "urchin," the surface of which is a little wider than that of the feeding roller. Were these points at right angles with the roller, they would be inclined upon the sliver opposite the feeding and delivery rollers. On the feed-roller side the ribbon would make its exit from the points at the moment the drawing was being done. Under such circumstances, the drawing would be very defective. For this reason, the points are given a slight inclination to the rear, so that their direction, opposite the delivery roller, shall be as nearly as possible at right angles with the slivers. But then the inclination opposite the feeding roller becomes too great, so that the points have difficulty in entering the sliver, and form loops therein. So this system is not very practical, except for very short staples, that permit of the use of urchins of small diameter.

Drawing Frames with Suns and Heckle Bars.—In this system the urchin is replaced by heckle bars actuated by two parallel disks, having radial guides through which pass the extremities of the bars. These disks, from their appearance, are styled "suns." Externally to and parallel with the suns are placed two other disks or guides provided with a slot with which engage the circular ends of the bars.

The suns, upon revolving, carry along the bars and give them a rotary motion. At the same time, as the ends of the bars have to follow the slot, the bars themselves are, through the form of these guides, compelled to move in the sun guides. It will be seen, then, that by means of these two well combined motions, it is possible at every moment to modify the direction of the points and give them, with respect to the sliver, a more suitable one than that obtained with urchins.

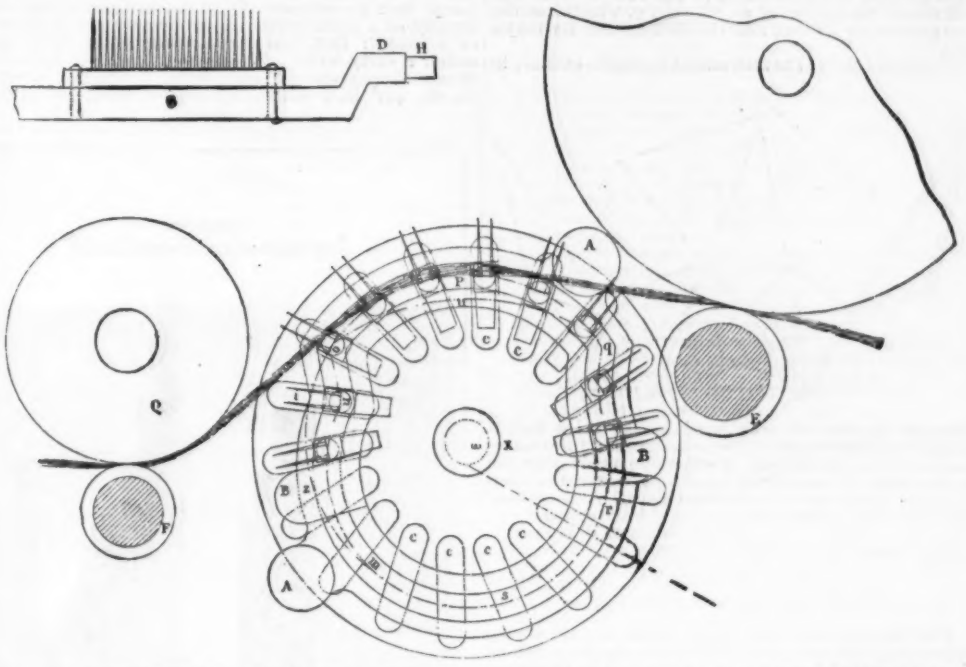


FIG. 2.—PRINCIPLE OF THE SUN AND HECKLE BAR DRAWING FRAME.

Description of Fig. 2.—*c c c*..... are the radial guides of the suns through which pass the flat parts, D, of the heckle bars. The axis of these guides does not pass through the center of the suns, but a little to one side, thus permitting of bringing the points a little nearer to right angles with the sliver on the delivery roller (E) side; *m*, *n*, *o*, *p*, *q*, *r*, *s*, *m*, is the median line of the slot which the ends, H, of the rods follow, and which is so outlined as to give the bars the position shown in the figure.

AA are the points of junction of the guides with the drawing frame.

BB are the points of junction of the inner portions of the guides with the outer ones.

As for the suns, they are keyed upon the rotary shaft, X.

E is the delivery roller, F is the feeding roller, Q is a cast iron pressure roller, and P a wooden pressure roller. G shows one of the combs fixed to the bars.

These sun and heckle bar drawing frames have been especially devised as an adjunct to carders, as these machines deliver their ribbons so fast that the latter cannot be taken up by screw drawing frames. In rotary drawing frames, as all the motions are circular, and the bars are not capable of coming out of their guides, quite a high speed may be obtained. Nevertheless, this system is far from being perfect. On the feed cylinder side, the points enter the sliver only in revolving; and, besides, in order that they may enter, it is necessary to give the sliver a strong tension, thus giving rise to loops again. On the delivery roller side, the sliver no longer makes its exit at right angles with the points, and on another hand, the distance between the place of exit and the point of contact of the delivery roller and of its pressure is considerable.

The necessary result, then, is that the work is not so perfect as with screw drawing frames.

In the ordinary guides, the center of the pivots, H, of the bars does not follow the line, *m*, *n*, *o*, *p*, *q*, *r*, *s*, *m*, that we have already indicated, but the line, *m*, *z*, *i*, *o*, *u*, *q*, *r*, *s*, *m*. The result is that the bars, starting from the point, *m*, revolve without side motion toward the sliver. They therefore do not puncture the latter, and do not penetrate it until after scratching it. Loops, then, must necessarily form.

On another hand, the part, *o u q*, is flattened instead of being circular, and the result is that, as *o* and *q* are more distant from the center than *u* is, the velocity at such points is greater than it is at *u*. The sliver, then, must fold together at *u*, and tend to escape from the combs. In order to obviate these drawbacks, the Messrs. Windsor Brothers, of Lille, a few years ago, made a modification in the guides, for which they took out a patent. Starting from the point, *m*, the center of the pivots of the bars approaches the center of revolution up to *n*, where it bifurcates, ascending to the straight line, *n o*, in the direction of the sliver, and follows the arc of a circle from *o* to *q*, where the bars fall. Owing to this arrangement, the sliver is not only punctured (thus permitting the tension between the feeding roller and combs to be considerably diminished), but likewise preserves a uniform velocity between the combs.

The application that has been made of these new guides to a large number of drawing frames has fully justified the expectations of the manufacturers. There are now being constructed sun and heckle bar drawing frames with two, three, and even four heads, with which three times the amount of production is being obtained that there is with the corresponding seven frames. These frames are especially employed for doubling. Our engraving (Fig. 1) represents a drawing frame of this kind with two heads. A part of the covering has been removed, in order to show that portion of the guides where the ricochet of the bars takes place.—*L'Industrie Textile.*

THE bee does not deface your fields by clipping the growing grasses, like the domestic animals; it does not mar the garden plants or levy taxes on your grain. Bees differ from the whole insect world. No tree, shrub, plant, or flower is injured by their presence.

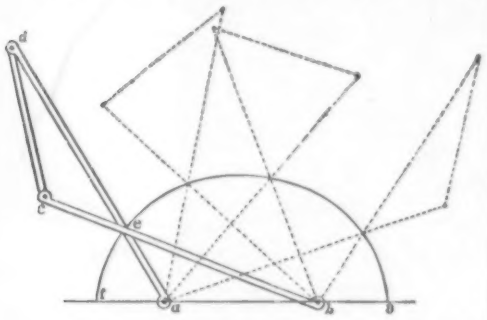
[FRANKLIN JOURNAL.]

A NEW ELLIPSOGRAPH.

THERE are so many ellipsographs and methods for draughting the ellipse, that a new one can hardly be said to be called for, but the study of the curve is interesting to many from a purely theoretical point of view, and the following device may be new to the subject. It is new to me, both as to its mechanism and its principle.

Four links, *a b*, and its equal, *c d*, *b c*, and its equal, *a d*, are joined together as in the figure, the points *a* and *b* being fixed. As the system is moved about the fixed centers, the intersection of the two crossed links will follow the outline of an ellipse, *f g*, which has the two centers for its foci, and the link *a d* for its major axis.

The figure shows the instrument in rough outline, to



illustrate its principle only, but it is easy to see that it would be adjustable for different ellipses if the centers were mounted on sliders, or otherwise made movable on the bars. It would also be a simple matter to attach a double slider that would slide on both the crossed bars and hold a pencil point at their intersection.

GEORGE B. GRANT.

Maplewood, Mass., August 29, 1886.

NEW FORM OF BATH TUB.

THE form of bath tub shown in the accompanying engraving, although new in this country, is in use on the continent of Europe, and particularly in Germany. For a sitting bath it has evident advantages in the way of convenience and ease to the bather. In the tub here illustrated, arrangement is made for heating facilities in

the seat; but this feature is not essential where other means exist for heating the water, and can be omitted at pleasure, while yet retaining the comfortable position afforded by the peculiar shape of the tub.—*The American Artisan.*

MARINE WOOL.

THE manufacture of articles from marine wool, or *bisso*, is an industry carried on, only on a limited scale, on the coast of Sardinia, and more particularly at the island of the Madalena. If the product was better known, it might become an important branch of trade, inasmuch as, from the softness of the texture of this substance, its natural color, and durability, *bisso*, instead of being, as it is now, a simple object of curiosity, merits a place in everyday use.

The *bisso*, or golden wool, is obtained from the *Pinna nobilis*, a mollusca belonging to a genus of shellfish which attaches itself to rocks and stones at the bottom of the sea by means of a tuft of a fibrous hair-like substance. This tuft is usually of a yellowish brown color, of a silk like texture, with a brilliant metallic luster, and is found in great quantities in the numerous little bays and creeks on the coast of Sardinia, and more especially on the shores of the islands of Caprera and La Madalena. The *pinna* is one of the largest bivalves found in the Mediterranean, and the great *pinna* is known at Madalena by the name of *gnacchera*, or *nacchera*; in the Venetian dialect as *gnaccara*, which name is probably derived from the Spanish *nacara*, signifying a sea shell; while the same word in that language, *nacre*, in French signifies mother of pearl. *Bisso* appears to have been known to the ancients, as Pliny, in his "Natural History," makes mention of its being found at Taranto, but as being little used.

The implement used for collecting this shellfish is simply an oval shaped ring of strong iron wire, called locally *ferro di nacchera*, which is fixed at the end of a rod from 15 to 20 feet in length, and the *pinna* is disengaged from the rocks and brought up to the surface by this instrument. The fish, which is somewhat indigestible, is used as an article of food by the fishermen, the edible part being well washed and rubbed on a rough surface in order to free it from a bitter-tasting substance of a reddish brown color which it contains, and called locally *pepe* (pepper).

The tuft of wool is then washed, first in salt water, in order to free it from the sand, fragments of shells, and other substances that may be entangled in its fibers, and after a second washing in cold water it is dried in the sun. When dry it is combed and the tuft remaining is cut from the root by which it is attached to the shell, and it is next spun like cotton, wool, or other textile substances. The combings also can be spun, but yield an inferior quality of yarn. The *bisso* is of two colors, or rather two shades of the same line particular to it, either dark or light, the latter being the most prized on account of the rich dark gold luster (*Vielle or*), from which its name "golden wool" is derived. On account of the small quantity in which it is collected, the little care taken in sorting, the stuffs made from this wool are often striped with dark and light shades. Oysters of excellent quality often attach themselves to the shells of the *nacchera*. These shells might be used as an inferior quality of mother of pearl. The pearls that are occasionally found in these shells are usually of a light brown or copper color, sometimes of a reddish tint, and more rarely of a white or rather a dirty white. The price of *bisso* is as follows: When simply washed and dried, 7 lire per kilog. (2s. 6d. per lb.); combed, 15 lire per kilog. (5s. 7½d. per lb.); and when carded and spun, 30 lire per kilog. (11s. 3d. per lb.). The cost of spinning is 7·50 lire per kilog. (2s. 7½d.). The fiber loses about 25 per cent. of its weight by combing and spinning.

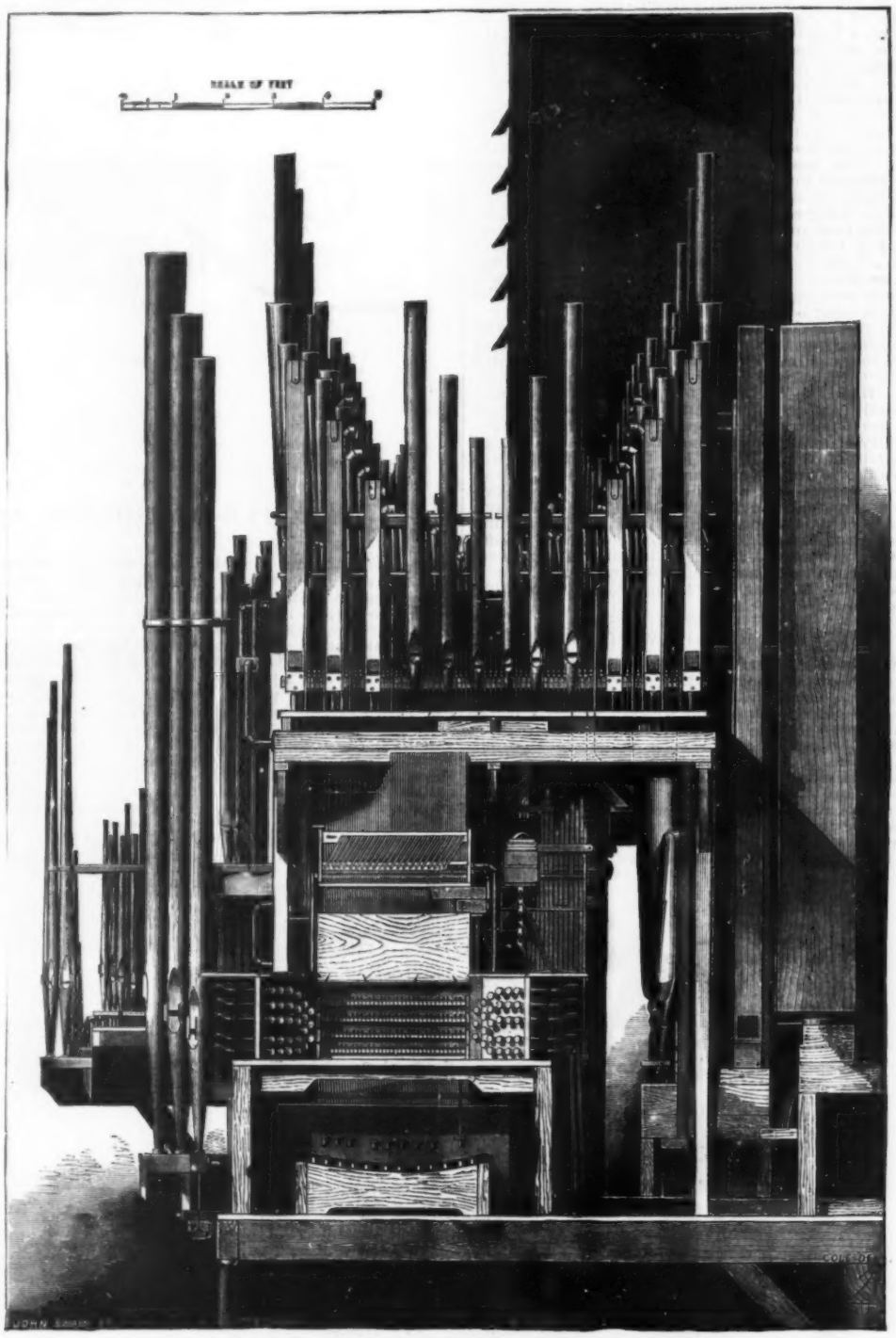
The price of articles manufactured from this wool are, cravats 5 lire each (4s.), small shawls from 25 lire to 30 lire (£1 to £1 4s.); they are extremely durable, and a shawl costing originally 60 lire (£2 8s.), which has been in constant wear in all kinds of weather for upward of twelve years, was lately seen by the writer.

SOME interesting facts have been published bearing on the retarding influences of cold on the development of insects, as seen in the Arctic regions. These observations have extended over several years, and show that butterflies, which, in the warmer regions of the earth, pass through all their transformations once or more in a season, take two or three years to complete a single cycle where the summer season is very short and the prevailing temperature low.

ORGAN IN THE LIVERPOOL EXHIBITION.

THE best organists agree that the duplication of stops, which marks the design of most organs of the present day, is a needless complication, rendering the organ less easy of management, and occupying valuable room indispensable for the free speech of the pipes.

It will be seen that in the present organ of Messrs. Mitchell & Thynne, of London, which has been justly termed a *multum in parvo*, there are but thirty-six sounding stops, yet it contains in itself capacity and grandeur surpassing many instruments of double its size, and this is due to the fact that no two stops in the whole organ are alike, but each possesses a strongly marked individuality and distinctive character of tone. Among its most prominent specialties, which are peculiar to this instrument, may be named the gambas and flutes. These will be found a perfect imitation of the violoncello in the solo organ, and the zauberflote in



ORGAN IN THE LIVERPOOL EXHIBITION.

the choir is a stopped harmonic flute of novel character and peculiar construction, possessing a tone which, when used as a solo stop, is strikingly telling, but when used in combination modifies wonderfully, and is curiously accordant with the softest stops.

The instrument consists of four manuals, choir, great swell, and solo organs, each for full compass, CC to C, with a pedal organ. The sound boards are so placed that each organ has ample speaking room. The choir organ, as will be seen from the front elevation, an engraving of which we publish, being prominently to the front, the delicate stops thus speak directly into the room without impediment, lending a charm which no other position would render possible. Above this organ is placed the great or chorus organ with its sonorous diapasons and brilliant mixtures, and at higher level the swell organ. The manuals are placed at the side of the instrument, with the basses toward the audience; and above these, as will be seen by reference to our engraving, is the solo organ, with a portion of the harmonic flute and violoncello forming a front.

At the back of this will be seen the tuba, a very fine reed able to assert itself over the full organ. The pedal organ may be seen to the side of the player, three stops of which are placed at the back of the organ, the 32's and great flute being on the other side. Immediately above the keys our engraving shows the tubular pneumatics as applied to the solo organ, which players pronounce to be perfect in promptness of touch and repetition. Tubular pneumatics of a similar kind are now applied to the swell with equal success, the great organ being commanded through by the ordinary or French pneumatic lever. Within the organ are four large reservoirs, two being placed under the great organ soundboard, with a main reservoir on lighter wind supplying the choir organ and basses of the great organ under these. Beneath the swell is the heavy pressure wind reservoir which feeds the reeds. Under the orchestra on which the organ stands are the bellows—six very large French feeders supplying two feed reservoirs, and worked by a 4 horse Otto gas engine. We give below, for the benefit of our readers, the blowing action as seen when the organ stood in the small concert room at South Kensington. The feeders will here be seen to be mounted on gun metal wheels, which allow them to work horizontally freely with a minimum of friction.

For the first time in any English organ, a mechanical movement of singularly simple and ingenious construction is applied to the great organ keys, by which the

Swell, CC to C in Alto—61 Notes. Swell Box made in Three 1 in. thicknesses, Felted between each and Lined.

		Ft.
1	Flauto traverso (metal)	8
2	Open diapason "	8
3*	Viole de gambe "	8
4*	Voix celeste "	8
5	Geigen "	4
6†	Mixture, 3 ranks, 15, 19, 22.	
7†	Contra posaune (metal)	16
8†	Horn "	8
9	Oboe "	8

ACCESSORY STOPS.

Super octave coupler.
1 Ventil fue to geigen.
2 " mixture and reeds.
Two pneumatic pistons acting on ventils, as in great organ.
Tremulant.
Three composition pedals.

Solo Organ, CC to C in Alto—61 Notes.

		Ft.
1	Harmonic flute (metal)	8
2*	Violoncello (metal and wood)	8
3	Tuba (metal) (heavy wind)	8
4	Voix humaine (metal, inclosed in a swell box)	8

ACCESSORY STOPS.

1 Super octave coupler.
Two ventils. Two pneumatic pistons, as in other manuals.
Tremulant.

Pedal Organ, CCC to F—30 Notes.

		Ft.			Ft.
1*	Harmonic bass (wood)	32	4	Great flute (wood)	8
2	Great bass "	16	5	Bombarde (metal) (heavy wind)	16
3*	Dolce " (wood open)	16			

Pedal Couplers.

1 Choir to pedals.
2 Great " on a double acting pedal.
3 Swell to pedals.
4 Solo "

ORGAN IN THE LIVERPOOL EXHIBITION.

player can at will retain any note or chord which he strikes, while his hands are free for another manual; and a second note or chord held on the same manual instantly releases the first one retained. Many beautiful and novel effects are capable of being thus produced. Two ventils or stops, governed by pneumatic pistons of double action placed beneath the keys, will be found to each organ in addition to the ordinary composition pedals, thus rendering the management of the instrument easy and thoroughly complete.

We append to this description a list of stops, as given by the builders. Every stop in this organ is complete in compass from CC to C in alto—61 notes. The stops marked * are of new construction:

Choir Organ, CC to C in Alto—61 notes.

		Ft.
1	Spitzflote (metal)	8
2*	Viole sourdine (metal)	8
3*	Gedact (wood)	8
4	Gemshorn (metal)	4
5*	Zauberflote "	4
6	Flautina "	2
7	Clarionet	8

ACCESSORY STOPS.

1 Ventil.
2 Super octave coupler.
3 Pneumatic piston acting on No. 1, off and on.
4 Swell to choir.
5 Tremulant.

Great Organ, CC to C in Alto—61 Notes. Supplied with Three Pressures of Wind.

		Ft.
1	Violon (metal)	16
2	Great open diapason (metal)	8
3	Small open diapason "	8
4	Claribel (wood open through)	8
5	Octave	4
6	Flute octaviante	4
7	Quint mixture, 12, 15.	
8†	Great mixture, 4 ranks, 19, 22, 26, 29.	
9†	Tromba	16
10†	Trumpet	8

ACCESSORY STOPS.

1 Sub octave choir to great.
2 Swell to great.
3 Solo to great.
1 Ventil, fine to quint mixture.
2 " great mixture and reed.
Two pneumatic pistons acting on ventils placed beneath the keys as in choir.
Three composition pedals.
*Prolongement harmonique.

†On heavy wind.

Manual Couplers.

1 Choir super octave (with choir stops).
2 Swell super octave (with swell stops).
Solo super octave (with solo stops).
4 Choir sub octave to great (with great stops).
5 Swell to great (with great stops).
6 Solo " (" ").
7 Swell to choir (" choir ").

The tremulants are brought on to the action of one pedal by the use of the draw stops, separately or collectively. The draw stops are of solid ivory with ebony knobs, placed diagonally so as to afford the greatest facility for management. The instrument is constructed throughout of the finest materials and workmanship.—*The Engineer.*

THE FULMINATING SILVER OF BERTHOLLET.

RASCHIG has studied the compound obtained by Berthollet nearly a hundred years ago by the action of ammonia upon silver oxide. For the preparation of the substance, a solution of silver nitrate was precipitated with sodium hydrate, and the silver oxide washed by decantation. For each gramme of silver nitrate used, there was poured upon the silver oxide 2 cubic centimeters of an ammonia solution containing 25 per cent. of NH_3. The oxide of silver dissolved readily, leaving only a slight turbidity. The solution thus obtained was divided into several portions, each being placed in a porcelain dish about 10 cm. in diameter, so proportioned that no dish contained the oxide from more than one gramme of nitrate. Each dish was covered with a watch glass and allowed to stand for 16 to 20 hours. The ammonia evaporated, and the fulminating silver was deposited as a black crystalline mass. After washing it was analyzed by digestion with very dilute sulphuric acid, by which a residue of metallic silver was generally left. The dissolved silver was precipitated with hydrochloric acid, and in the filtrate the ammonia was determined as platinochloride. The result of sixteen analyses gave ratios which were very close to three atoms of silver for one of nitrogen; leading to the formula NAg_3. Other samples of the substance prepared by warming the ammonia solution of the silver oxide on the water bath, or by precipitating it with alcohol, gave the same ratio on analysis. It exploded by the slightest concussion when dry, and requires great caution in handling even when moist. It is soluble in ammonia and in potassium cyanide.—*Liebig's Ann.*

SONG OF THE CHEMIST.

I LOVE thee, Mary, and thou lovest me;
Our mutual flame is like the affinity
That doth exist between two single bodies.
I am Potassium to thine Oxygen.
'Tis little that the holy marriage vow
Shall shortly make us one. That unity
Is, after all, but metaphysical.
Oh, would that I, my Mary, were an acid,
A living acid; thou an alkali
Endowed with human sense, that, brought together,
We both might coalesce into one salt,
One homogeneous crystal. Oh, that thou
Wert Carbon, and myself were Hydrogen!
We would unite to form olefiant gas,
Or common coal, or naphtha. Would to heaven
That I were Phosphorus, and thou wert Lime,
And we of Lime composed a Phosphoret!
I'd be content to be Sulphuric Acid,
So that thou might be Soda; in that case,
We should be Glauber's Salt. Wert thou Magnesia
Instead, we'd form the salt, that named from Epsom.
Couldst thou Potassa be, I Aquafortis,
Our happy union should that compound form,
Nitrate of Potash—otherwise Saltpeter.
And thus our several natures sweetly blent,
We'd live and love together, until death
Should decompose the fleshy tertium quid,
Leaving our souls to all eternity
Amalgamated. Sweet, thy name is Briggs
And mine is Johnson. Wherefore should not we
Agree to form a Johnsonate of Briggs?
We will. The day, the happy day, is nigh!
When Johnson shall with beauteous Briggs combine.

—*London Punch.*

TELESCOPIC OBJECTIVES AND MIRRORS.—PROPOSED OBSERVATORY FOR MOUNT HAMILTON.

MR. HOWARD GRUBB, F.R.S., recently delivered a lecture at the Royal Institution upon "Telescopic Objectives and Mirrors: their Preparation and Testing." Dr. William Huggins, F.R.S., presided.

The lecturer said that time would not permit him to go into the history of the development of the methods of constructing telescopic objectives, but a few words on the history of optical glass manufacture were necessary. Dollond's discovery of the means of achromatizing objectives rendered possible their construction of larger size, provided suitable material could be obtained, for his discovery rendered visible faults which had previously been masked. Many years then elapsed before Guinand, a persevering Swiss peasant, succeeded in producing good disks of glass of suitable dimensions. His secret he handed down in his own family to M. Feil, of Paris, one of his descendants, and also through M. Bontemps, who for a time was associated with Guinand's son, and afterward accepted an invitation from Messrs. Chance Bros. & Co., of Birmingham, to assist them in an endeavor to improve this branch of their manufacture. Only these two houses, so far as he knew, could make optical disks of large size.

The glass disks when received by the optician have to be tested. Sometimes, when received, they are roughly polished on both sides; sometimes they have but small facets polished on the edges. For telescopic lenses it is best to have them polished on both sides, to avoid the risk of having to throw a lens away after much trouble and labor have been expended upon it. The points to be looked to are: (1) air bubbles, specks, and mechanical impurities; (2) homogeneity; (3) annealing. The first of these can be seen by the eye. The test for homogeneity is somewhat equivalent to Foucault's test for the figure of concave mirrors. The disk of glass should either be ground and polished into a convex lens, or it should be placed in juxtaposition with a convex lens of similar or larger size, of known good quality. A small brilliant light is placed opposite one side of the lens, so that the conjugate focus is found on the other side at a convenient distance. A small gas flame will do as the source of light. When the image of the flame is thus brought upon the pupil of the eye by the lens, the lens should appear to be "full of light," but at the slightest movement to one side the lens should appear quite dark. If the eye be now slowly passed backward and forward between the positions showing light and darkness, any irregularity of density will be easily seen, but some experience is necessary. If any portion of the lens be of a different density to the general mass, that portion has a larger or shorter focus, revealed by luminosity, while the rest of the lens appears dark. He had sometimes succeeded in photographing such defects in the camera.

Annealing is tested by the polariscope, the disks of small size being examined through the facets, by means of a polarizing plane and a Nicol prism. Larger sizes, polished on the surfaces, can be more easily examined, and their defects become visible in the lantern polariscope. Mr. Grubb here projected upon the screen a polarized image of a badly annealed disk, which was traversed by a black cross, and by rings of color near the circumference. He said that opticians never expected to get quite rid of the black cross, but that if any colored rings appeared, the glass was rejected.

The composition of the metallic mirrors of the present day differs but little from that used by Sir Isaac Newton. The best alloy is now made in the proportion of four chemical atoms of copper to one of tin. The curves of lenses have to be calculated for focus,

and for the correction of the chromatic and spherical aberrations. In many published works full information is given as to the calculation of the curves; and, contrary to a general illusion, there is no difficulty or mystery about the matter. The calculation of the curves which satisfy the conditions of achromatism and desired focus is a most simple one, and can be performed in a few minutes by any one having a slight algebraical knowledge, provided the refractive indices and dispersive power of the glass be known. Both Messrs. Chance and Messrs. Feil supply these data with their disks, quite sufficiently accurate for small-sized objectives, and he accepted their figures for any disks up to ten inches in diameter. When above that size, he obtained his data from personal measurements. The calculations of the curves for spherical aberration are very troublesome, but fortunately they may generally be neglected. Some years ago the Royal Society commissioned one of its members to draw up tables for the use of opticians, giving curves to satisfy all the conditions they required. The plan was abandoned because the surfaces produced by opticians are, in most cases, not truly spherical. Objects glasses cannot be made on paper; the final corrections must be left to the optician, and not to the mathematician.

A sensible difference in correction for spherical aberration can be made in half an hour's polishing. He would be willing to undertake to alter the curves of the crown or flint lens of any of his objectives, by a very large quantity, increasing one and decreasing the other, so as to still satisfy the conditions of achromatism, but introducing theoretically a large amount of positive or negative spherical aberration, and yet to make out of the altered lens an object glass perfectly corrected for spherical aberration, so far as ordinary sizes are concerned. Even for large sizes it is sometimes possible to make a better lens by deviating from the curves which give a true correction for spherical aberration, and correcting that aberration by "figuring." The work of making a lens is divided into (1) rough grinding, (2) fine grinding, (3) polishing, (4) centering, (5) figuring and testing. In the rough grinding the disks are cemented to a holder, and ground with sand and water. For fine grinding the tools are of brass or iron; he preferred iron, except for very small sizes. The tools are grooved on the face, in the manner suggested by the late Mr. A. Ross, in order to allow the grinding material to properly distribute itself. If two spherical surfaces be rubbed together, or rubbed together with dry powder between, they will tend to keep spherical; but if wet powder be used, they will abrade more on the center and edge than in the zone between. Mr. A. Ross designed the distributing grooves to meet the difficulty.

The particles of the grinding powder are either embedded in the softer surface, or are rolling between the two surfaces, or are sliding between the two surfaces. The particles which become embedded are the finer, and do little work; most of the work is done by those which slide; as the grinder is made of a softer material than the glass, they partially adhere to the former, and are carried by it across the face of the latter. The best conditions for rapid grinding are: not too little emery, for then there will not be enough of abrading particles; not too much, for then the particles will roll on each other and tend to crush and disintegrate each other instead of abrading the glass; there should be just sufficient to form a single layer of particles between the grinder and the glass surface. Lenses less than 5 in. or 6 in. in diameter are usually ground by hand, and it is possible to grind by hand surfaces up to 12 in. or even 15 in., but the labor is severe. He was gradually reducing the size allotted to hand grinding. He found machine grinding to be more constant in its results. The machinery used is the same as for the subsequent polishing.

In fine grinding operations by hand the glass is usually cemented to a holder, having for smaller sizes three pieces of cork to which the lens is attached. This holder is screwed to a "spud" or nose on the top of a post screwed to the floor. The operator applies the proper quantity of moist emery, then works the grinder over the glass in a set of peculiar strokes, the amplitude and character of which he varies according to circumstances, at the same time that he changes his position round the post every few seconds. The grinder suffers abrasion as well as the glass, and the skill of the operator is shown by the facility with which he is able to bring the glass to the curve of the grinder without altering the curve or figure of the latter. A skilled operator can even take a lens of one curve and a grinder of, say, a deeper curve, and produce surfaces fitting together, and of shallower curves than either.

In the early stages of grinding, gauges of the proper radius, and cut out of sheet brass or sheet steel, are used for roughly testing the curves of the lenses. For more accurate purposes a spherometer is used. It is made in various forms, generally with three legs terminating in three hardened steel points, which lie on the glass, and a central screw with fine thread, the point of which can be brought down to bear on the center of the glass. The versed sine of the curve for a chord equal to the diameter of circle formed by these points is measured. The radius of the curve can then be easily calculated. He did not find the points of the spherometer satisfactory for regular work. They are apt to get injured or worn, and on ground surfaces one or other of the feet may find its way into a deep pit in the lens. His spherometer, then exhibited, had three feet of about $\frac{1}{16}$ in. each, which feet were hardened steel knife edges forming three portions of an entire circle. After its three curved feet are placed upon the lens, the screw with the micrometer head is turned till the point is felt to touch the surface of the glass. The scale and head can then be read off. The screw in the instrument has fifty threads to 1 in., and the head is divided into 100 parts, so that the division is equal to $\frac{1}{5000}$ in. With practice it will measure to one-tenth of this, or $\frac{1}{50000}$ in., and by special precautions even perhaps $\frac{1}{100000}$ in. or $\frac{1}{150000}$ in., which he had found to be practically the limit of the accuracy of mechanical contact. To show the delicacy of the instrument, he brought its movable center and its three feet to bear equally upon a curved glass surface; when then blown upon with air of the temperature of the theater, the spherometer would not move without sliding bodily on the glass. He then raised the spherometer by means of a string so as not to alter its temperature, and placed his hand for a moment on the center of the glass; on replacing the spherometer, a puff of air made it turn upon its central crew, because the latter rested upon the lump produced by the warmth of the hand upon the center of the glass.

Flexure during polishing causes great difficulties, but even the thick pieces of glass used for lenses will bend with their own weight. He placed the spherometer upon a disk of glass of about 7½ in. diameter, and ¾ in. thick, so that the instrument would not turn, the disk then resting upon three blocks near its periphery. He next placed a block under the center of the disk and removed the three others. The spherometer would then spin round upon its central screw. The spherometer is too coarse an instrument to be of use in figuring objectives. For small sizes no special precautions are necessary to prevent the effects of flexure in grinding, but for all sizes over 4 in. in diameter he used the equilibrated levers devised by his father, and utilized for the first time on a large scale in supporting the 6 ft. mirror of Lord Rosse's telescope. He had also sometimes polished lenses while they were floating on mercury, but it was difficult to keep the disks sufficiently steady without introducing other chances of strain. Very large lenses, when placed in their cells, suffer flexure from weight alone, as they then are supported nowhere but at the edge; he therefore once proposed to make the telescope tube air-tight, and to introduce air at a slight pressure to form an elastic support for the objective, the pressure to be regulated automatically according to the altitude. His attention was directed pointedly to this matter, when he was obliged to use for the Vienna 27 in. objective a crown lens which, according to ordinary rules, was much too thin. He had waited some years for the disk, and none thicker could be obtained at the time. If it had been offered to him in the first instance, he would have rejected it. To his surprise he found that he was not troubled by flexure in the working, which led him to investigate the matter, with the following curious results.

If we call f the flexure for any given thickness, t, and f', the flexure for any other thickness, t', then $\frac{f}{f'} = \frac{t^3}{t'^3}$ for any given load or weight approximately. But as the weight increases directly as the thickness, the flexure of the disks due to their own weight, which is what is wanted to be known, will be about as $\frac{f}{f'} = \frac{t}{t'}$.

In relation to the effect of this flexure on the image in any lens bent by its own weight, whatever part of its surface is made more or less convex or concave by the bending has a corresponding part bent in the opposite direction on the other surface, which tends to correct the error produced by the first surface. This is one reason why reflectors, which have not this second correcting surface, are so much more liable to show strain than refractors. If the lens were infinitely thin, moderate flexure would have no effect upon the image; the effect increases directly as the thickness. As the flexure decreases directly as the thickness, and the effect of that flexure increases directly as the thickness, it is clear that the effect of the flexure of any lens due to its own weight will be the same for all thicknesses. In other words, no advantage is gained by additional thickness. What has just been stated has nothing to do with the extra difficulty of supporting a thin lens during the grinding and polishing processes.

The speaker then dealt with the subject of the substances used for the face of the polisher. Cloth is sometimes used, sometimes pitch, and the French are said to employ paper. The ground surface of a lens consists of a multitude of hills and valleys. Cloth not only polishes the tops of these hills, but, as it has a "nap," polishes them at the same time a little way down their sides; hence the lens seems to polish quickly with cloth, and looks well when the surface is in reality uneven. Pitch polishes down the tops of the hills, scarcely touching their sides, and with it polishing goes on for some hours without much perceptible advance, for the hills are being slowly shaved down; suddenly the remaining grayness disappears, and the surface is polished. He had not succeeded well with paper, which indeed was open to the same objections as cloth. Sir Isaac Newton was the first to use pitch for the polishing of lenses, and it seems to be the only known substance which will fulfill all the required conditions. The pitch used is not gas-tar pitch, but the natural bituminous substance which comes to England from Archangel. By continued boiling it can be made so hard that it cannot be scratched by the finger nail; yet if laid upon an uneven surface it will, in a few days, or weeks, or months, subside and take the form of that surface. Hence pitch has more of the qualities of a liquid than of a solid. The polishing tool is made by overlaying a metal or wooden prism formed to nearly the required curves by a set of squares of pitch, and while these are still warm pressing them against the glass, the form of which they immediately take. When it is desired to lessen the polishing abrasion in particular places, it is done by modifying the sizes of the squares of pitch in particular zones with a knife and mallet.

The two best known polishing machines are those of the late Earl of Rosse and the late Mr. Lassell. Many years ago his (Mr. Grubb's) father devised a machine, figured and described in Nichol's "Physical Science." All these machines, notwithstanding the curves of motion, were liable to polish in rings, so in the latter he had made a modification to overcome the drawback. Here, by the aid of the electric lantern, he projected on the screen diagrams of the curves described by the various instruments. He also drew attention to a diagram representing a section of a lens of about eight inches aperture and one inch thick, magnified 100 times, to show the relative thickness of material abraded by the four processes. The quantity removed by rough grinding was represented by a band 25 in. wide, the fine grinding by one $\frac{1}{8}$ in. wide, the polishing by a line $\frac{1}{16}$ in. wide, while the quantity removed by the figuring process could not be shown even on this scale, as it would then be represented by a line only $\frac{1}{1000}$ in. thick. The approximate cost of the abrasion of a gramme of material by each of the four processes is: Rough grinding, about 1d. per gramme; fine grinding, 7½d. per gramme; polishing, 10s. per gramme; figuring, £48 per gramme.

The figuring process is that of correcting local errors in the surfaces, and the bringing of the surfaces to that form, whatever it may be, which will cause the rays falling on any part to be refracted in the right direction. It is an occasional, but exceedingly rare, thing for an objective to prove perfect on the first trial, but they usually gave such results when first tried that he considered them to be but three-fourths finished. The figuring consists of: (1) The detection and localization of faults; (2) the altering of the figures of the different surfaces to cure the faults. In the case of a 27 in. objective of 34 ft. focus, say that there is an error in the center of one surface of about 6 in. diameter, which causes the focus of that part to be $\frac{1}{10}$ in. shorter than the rest. For the sake of simplicity, say that the surface is generally flat; the central 6 in. of the surface therefore, instead of being flat, must be convex, and of over 1,032,000 in. radius, about 17 miles. The versed sine of this curve, as measured by the spherometer, would be only about $\frac{1}{250000}$, 4 millionths of an inch, a quantity in his opinion mechanically unmeasurable. If the error had been spread over three instead of six inches, the versed sine would only be about $\frac{1}{2000000}$: probably its effect on the image would not then be appreciable, but a similar error near the edge of the objective certainly would be appreciable. No known mechanical arrangement is delicate enough to measure these quantities; optical devices are therefore necessary, and trials of the objective or mirror on a telescope are really the crucial test. The best object to employ is generally a star of the third or fourth magnitude; but as in this climate it frequently occurs that no such star is visible, a minute image of the sun reflected from a little polished ball, or even a thermometer bulb, will do. Small electric lamps, with their light condensed and thrown upon a polished ball, are useful.

For the localization of errors, sets of diaphragms which leave exposed various zones on the surface, the foci of which can then be separately measured, are useful, but a really experienced eye does not need them. For concave surfaces Foucault's test, described in Dr. Draper's and other books, is useful; but is not available for convex surfaces, and only partially available for concave parabolic surfaces. The detection of one fault in an objective is easy, but usually many are superimposed; it would be impossible in one lecture to state all the methods of localizing faults, but he would mention some that had never previously been made public. To detect faults of symmetry, revolve one lens on another and watch the image; it can then generally be ascertained whether the fault is in the flint or crown lens. With some kinds of glass the curves necessary for satisfying the conditions of achromatism and spherical aberration are such that the crown becomes an equi-convex and the flint a nearly plano-concave of the same radius on the inside curve on either side of the crown. This form is a most convenient one for the localization of surface errors in this manner. The lenses are first placed in juxtaposition and tested. Certain faults of figure are detected. Now, calling the surfaces A, B, C, D, in the order in which the rays pass through them, place them again together with Canada balsam or castor oil between the surfaces, B and C, forming what is called a cemented objective. If the fault be in either the A or D surface, no improvement is seen; if in B or C, the fault will be much reduced or modified. Now reverse the crown lens, cementing the surfaces, A and C, together. If the same fault still shows, it must be in either B or D; if it does not show, it will be in either A or C. From these two experiments the faults can be localized.

Sometimes a suspected error is so slight that it appears problematical whether an alteration would improve matters or not. He had devised methods, for use in some such cases, of temporarily altering the surface. If he suspects a certain zone on an objective to be too low, he passes his warm hand six or eight times round that particular zone. This usually raises the surface too much at first, but the observer at the eye end can watch the results as the effect passes off. To lower any part of the surface he paints on sulphuric ether with a camel's hair brush, blowing on it slightly; this gives as much cooling effect as necessary. The next point is the remedy. The lens is again put on the polishing machine, the pitch patches and the stroke are modified so as to tend to reduce the surface where desired. All thanks are due to Lord Rosse, Mr. Lassell, and Dr. De la Rue, for having published all about the figuring process which it is possible to communicate; but those who have succeeded in this work have had to strike out new lines for themselves, hardly one having attained notable success by following the instructions bequeathed by others. Some Continental workers are said to use small polishers and local touch in the figuring. The method is useful in removing gross quantities, but he would not employ it for the final perfecting of the surface. In working at the Vienna objective, it often happened that the figure was so nearly perfect that it was dangerous to carry on the polishing process for more than ten minutes between each trial, but then it was sometimes necessary to wait for a week before the atmosphere became steady enough to allow the trial to be made to determine whether the ten minutes' working had done harm or good. In a few days the work of weeks may sometimes be undone.

In making a new 28 in. objective for the Royal Observatory at Greenwich, he intended to make provision for the reduction of these troubles. The greatest difficulties are the want of atmospheric homogeneity, because of varying hygroscopic and thermoscopic states, and sudden changes of temperature in the polishing room. The polisher must always be made of a hardness corresponding to the existing temperature. It takes about a day to form a polisher of large size, and if before the next day the temperature changes 10 deg. or 15 deg., as it often does, that polisher is useless, and a new one has to be made, and perhaps before it is completed another change of temperature occurs. To grapple with these difficulties, he proposed to have the polishing chamber underground, and leading from it to have a tunnel formed about 350 ft. long of highly glazed sewer pipes, at the end of which tunnel is placed an artificial star illuminated by the electric light; on the other side of the polishing chamber is a shorter tunnel forming the tube of the telescope, terminating in a small chamber for the eye pieces and the observer. About half way in the long tunnel there will be a branch pipe connected to the air shaft of the fan, which is used regularly for blowing the blacksmith's fire, and through this, when desired, a current of air can be sent to "wash it out," and mix up all currents of varying temperature and density. It may be found necessary even to keep this

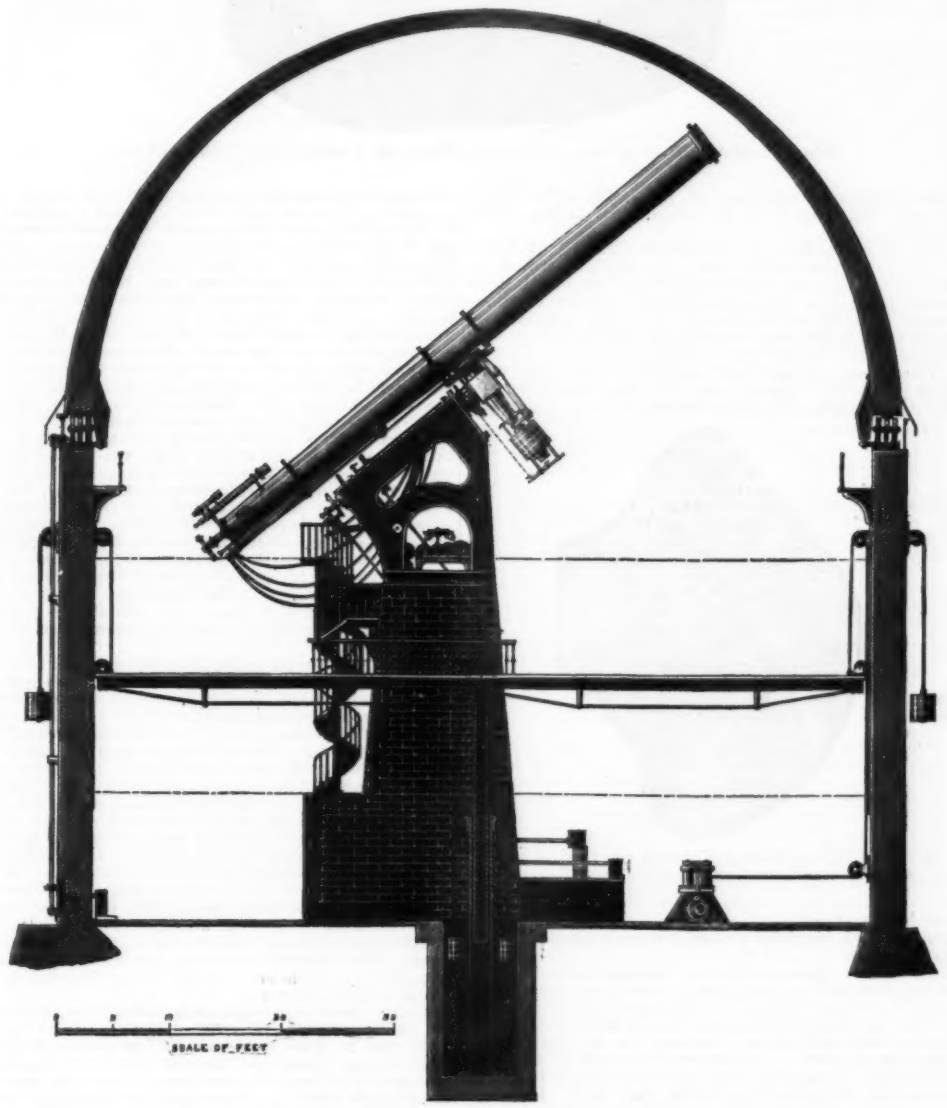
going during observations. By this arrangement he hoped to be able to have trials whenever required, without waiting hours or days for a favorable moment.

PROPOSED OBSERVATORY FOR CALIFORNIA.

After stating that the general idea that the working of a plane mirror is more difficult than one with curves is not quite correct, the lecturer drew attention to a working model of a proposed observatory for Mount Hamilton, in California. [An engraving from Mr. Grubb's design for this observatory is given herewith, from the *Engineer*.] A Mr. Lick has left a large sum of money for the erection of a monster observatory, which is already partly complete, and contains some excellent instruments of moderate size, the work already done with which favors the idea that the great 36 in. refracting telescope about to be erected there will be placed under more favorable conditions for observations than any other large telescope in the world. The trustees of the Lick Observatory had invited him to design an instrument for the 36 in. objective now in course of construction by Messrs. Clark, of America, the contract for the mounting not having yet been made, and in the model he had put his ideas into practical form. The conditions he laid down for himself in designing the observatory were that it should be possible for the observer single-handed to enter the equatorial room at any time, and that, without using more physical exertion than is necessary for working the smallest sized telescope, or even a table microscope, he should be able to open the 70 ft. dome, turn it round backward and forward, point the equatorial to any part of the heavens, revolving it in right ascension and declination to any extent, and finally, the most difficult of all, to bring his own person into a convenient position for observing. There is generally far more trouble in moving the observatory "chair" and placing it in proper position than in pointing the instrument itself. In this instrument the chair would require to be 25 ft. high, and with its movable platform, ladder, balance weight, and so on, would weigh probably some tons. Even if very perfect arrangements were made for the working of this chair, the mere fact that the observer while attempting to make the most delicate observations is perched upon a small and very unprotected platform 25 ft. above the floor, and in perfect darkness, tends to reduce his value as an observer to an extent only to be appreciated by those who have undergone the trial. Personal comforts and discomforts have much do with the value of observations.

He proposed that all the various motions should be effected by water power. Some water engines have no dead point, and, having little *vis inertiæ*, are easily stopped and started. He proposed to use four of them; one for the right ascension motion of the instrument, and one for the declination; one for revolving the dome, and one for raising or lowering the observer himself; but instead of having anything of the nature of a 25 ft. chair or scaffold, he proposed to make the 70 ft. floor of the observatory movable. It is balanced by counterpoise weights, and raised and lowered at will by the observer. Then the observer can without any effort raise and lower the whole floor, carrying himself and twenty people, if desired, to whatever height is most convenient for observation, and wherever he is observing he is conscious that he has a 70 ft. floor to walk about upon, which even in perfect darkness he can do in safety. The valves and reversing gear of the water engines are actuated by a piece of mechanism, the motive power of which may be a heavy weight raised into position some time during the previous day by man or water power. By means of a simple electrical contrivance, this piece of machinery is under the complete control of the observer, in whatever part of the room he may be, and he carries with him a commutator of a compact and convenient form, with eight keys in four pairs, each pair giving forward or backward movements at will to the portion of the observatory appliances intended to be controlled. The shutter of the dome moves back horizontally. To open it, it is but necessary to anchor it to a hook in the wall, and to move the dome in the opposite direction.

Supposing the telescope to be in a vertical position, and the observer at the eyepiece to accidentally start the machinery for raising the floor, it would be bad for him. So safety apparatus had been devised, which after the floor had been raised to a particular level, would cut off all the water power of the establishment. At the same time, a certain amount of intelligence in the operator has to be assumed.



PROPOSED OBSERVATORY, MOUNT HAMILTON, CALIFORNIA.

The remark had been made to him that by laying bare the particulars of his work, men would pick up his trade secrets. Up to the figuring, the processes were purely mechanical; but the last process was something beyond mechanical work. A person might spend a year or two watching every detail of the manufacture of large objectives, see every part of the process, and take notes, yet he could then no more expect to figure an objective himself than a man could expect to be able to paint a picture because he had been sitting in an artist's studio for the same time watching him at his work. The art can only be learnt by experience, and then only by particular persons. He agreed with an experienced amateur who said that nine years' hard work was necessary to acquire the experience. It is true that some large objectives are turned out by machinery; but what kind of an objective can be turned out by a machine left to inexperienced hands? At the risk of being accused of working by rule of thumb, he confessed that conditions often arose to meet which he seemed to know intuitively what ought to be done, what crank to lengthen, what tempering is required of the pitch square, yet would find it difficult to give a reason satisfactory even to himself; and over every new objective he had found some new set of conditions to be then met by newly devised arrangements. A well known English astronomer once told him that he considered a large objective as much a work of art as a fine painting.

A LOOK THROUGH THE GREAT OBJECT GLASS.

By Professor C. A. YOUNG.

THE object glass of the great Lick telescope is now practically completed, and only awaits examination and approval by the experts who are to be appointed by the Lick trustees to test it. As all our readers probably know, this enormous lens, by far the largest ever made, is thirty-six inches in diameter, and has a focal length of fifty-seven feet. It is composed of two lenses, of which the front one (outside) is an equiconvex lens of crown glass, while the other is a concave lens of flint glass. One side of this—the one next the eye—is very slightly concave, in fact almost flat; the other, next the crown glass lens, is considerably concave, the curvature being somewhat deeper than that of the crown glass surfaces. The inner surfaces of the two lenses are separated by a clear air space of about six and a half inches, and there are perforations in the steel cell which allow a free circulation of air between them. The glass disks were made by Feil, of Paris, and they have been figured and worked by our own Clarks at their modest, but famous, establishment in Cambridgeport.

Through their courtesy, the writer had the privilege of looking through this most powerful of all existing telescopes a few evenings ago, in company with some of his astronomical friends; and although the state of the air was not all that could be desired, and the moonlight interfered somewhat with the view of faint objects, yet the experience was something to be long remembered.

The instrument is mounted on a temporary stand, first erected for the testing of the thirty-inch Poulkowa glass, which, until within a week or two, was the largest in existence. In constructing this mounting, the Clarks, however, had also the Lick instrument in mind, and proportioned the parts accordingly. A huge pyramid of brickwork rises some thirty feet from the ground, and bears on its sloping top a sort of cast iron saddle with the bearings of the polar axis, which is ten or twelve inches in diameter, and some twelve feet long. It carries at the upper end the declination axis, of about the same dimensions as itself. The tube of the telescope, an immense cylinder of boiler iron, forty-two inches in diameter, and nearly sixty feet long, is secured to one end of the declination axis, as near the pier as possible; and the other end of the axis, protruding awkwardly, is loaded with counterpoising weights.

As we came into the garden where the instrument is placed, the great tube towered high and white in the moonlight far above the surrounding trees and buildings, directed toward the bright star Alphacca, the gem of the Northern Crown. At the lower end, two or three men were sitting around; and one was lying on the ground, craning his neck to look into the eyepiece, which came a little too low to allow the use of the chair. The observer was Mr. Alvan G. Clark, the youngest member of the firm, and the one who at present does most of the purely optical work. He was trying to see how the figure of the lens had been effected by the delicate work of the last two or three days. The other onlookers were Mr. George Clark, his older brother, the mechanician of the firm, and the venerable Alvan Clark, Sr., their father, with one or two of the most trusted workmen of the establishment. Before long we were joined also by Professors Pickering and Langley.

In a few minutes the glass was turned to a neighboring star, γ Coronæ, which is an exceedingly close double, its components not being more than about ¼″ apart. Although the roughly mounted telescope vibrated a good deal in the breeze, and the air was rather unsteady, so that the star blazed and danced about, yet under a power of about a thousand the two components were distinctly separated with a fine dark line between them. I had seen the object just as *plainly* with a different instrument not very long ago, but not so impressively; the stars had no such brightness. In fact, the Lick object glass gathers in from any star nearly two and a half times the light collected by the Princeton glass, the areas of the lenses being as 1,296 to 529.

Everything about the image showed that the figure of the lenses is excellent, and the aberrations nicely corrected. Nobody but a Clark would think he could improve it "just the least bit."

Then we turned to the great cluster in Hercules, and wished that for a few moments we could extinguish the moon. For although the telescope resolved the cluster in a marvelous manner, and showed its own optical excellence in the perfection of the images, yet the moonlight and the haze robbed the object of its glory. The blaze and glow of the innumerable stars upon the black background of a darker night were missing.

The instrument was next directed upon ζ Hercules, an interesting and rapidly moving binary; and then upon the great white star Vega, or α Lyræ, at that time nearly in the zenith, and admirably adapted for testing purposes. This defied the moonlight; one understood now what Herschel meant in speaking of Sirius coming into the field of one of his great reflectors "*like sunrise*."

And yet, when the glorious star was passing through the field, one could see at the same time, and without any need of hiding the larger luminary, the delicate companion discovered by Winnecke long ago with the old Poulkowa telescope. Hitherto it has been possible to see this, even in the very largest telescopes, only when the great star was put out of the field. Of course we do not refer to the old and well known companion, easily seen in all telescopes of any size above four inches. In the great telescope, that was about as bright as the polar star to the naked eye. Nothing was seen, however, of other little stars that have been reported by certain amateurs as visible in this field of view.

On withdrawing the eyepiece, and placing the eye in the focus of the great lens, one could examine it critically for every vein and flaw and air bubble. It is rare that one finds a pair of disks so perfect. Under the trying test, one could indeed make out a few little wisps of veiny structure, and one small dark speck that was easily visible; but there was nothing that could do any mischief to the image of a star.

ε Lyræ, the exquisite double-double very near to

Vega, was next looked at; the only notable thing being that certain little stars between the two pairs, which in large instruments, but not *so* large, are rather hard to see, even in a dark night, were easy and almost conspicuous, notwithstanding the moonlight.

The "Ring nebula" was very pretty, but a mere pale ghost of what it would have been on a moonless sky.

α Herculis showed its contrasting colors finely; and, by putting the large star out of sight, we could see a little companion which Mr. A. G. Clark has just discovered; it is in the N. P. quadrant, and about 10″ or 12″ distant from the larger star of the pair. Probably it can be seen by some of the other large telescopes under favorable conditions, but it is certainly a full magnitude smaller than Winnecke's companion of Vega.

A number of other objects were looked at, but nothing that calls for special notice here.

The elder Clark remained present during the whole evening, and despite his eighty-three years examined every object, even when the position required was such as to cramp and try younger limbs and muscles. His eye seems to have lost little of its original keenness, though trembling hands and easy weariness no longer permit him to do much actual labor. But what a step from his first three inch glass made for Dr. Wells, of Salem (in 1850, I think), to his great three foot lens!

Toward midnight, when the time came to leave off work, the telescope was turned vertically, object glass down, and strapped tightly to the pier. In this position the lens was about eighteen inches from the ground, on which was a floor of heavy plank. A sort of low baggage truck was then rolled under the telescope, and, by a stout screw underneath, the floor of the truck was raised until it touched the cell which holds the lenses. On loosening the screws which hold the cell to the tube, the weight of the object glass, about 750 lb., settles down upon the truck; and when everything is clear, three men haul it away along a plank walk, and store it, with its sixty thousand dollar burden, in the little fireproof building where the grinding and polishing are done.

While the making of the great lens has gone on thus rapidly and successfully since the crown glass disk was received, only about a year ago, the opticians have just met a serious setback in the matter of the "photographic corrector," which was to go with it, and fit it for astronomical photography. The disk out of which this lens was to be made was received from Feil last spring. Examination by polarized light showed that the glass was under a severe internal strain, due to insufficient annealing; and the Clarks at once notified the maker of the fact, and told him that they feared the disk would not bear working. The maker, however, thought otherwise, and directed them to proceed at his risk, which they did. The upshot of it was that, a few days ago, the disk burst into three pieces while on the grinding tool; and so, of course, that part of the work will have to be postponed until a new disk can be obtained; how long that will take, no one can predict with certainty.

This will not, however, delay the erection of the instrument. Its mounting is already well under way in the shops of Warner & Swazey, at Cleveland; and, unless there is some unexpected delay about the observatory building and dome, there is every reason to expect that, within a year from now, this monstrous piece of astronomical artillery will have opened fire upon the heavens from its chosen mountain top. We may well hope that, under the able direction of Professor Holden, it will prove effective.

ON A METEORIC IRON FROM SOUTH CAROLINA.

By WILLIAM EARL HIDDEN.

THE meteorite here described and illustrated "was found, in the year 1857, in the northwest corner of Laurens County, South Carolina, and was deposited in the cabinet of the Laurensville Female College, at Laurens C. H., very soon after its discovery. It was sent to the New Orleans Exposition of 1884–85, where it formed a part of the State exhibit of South Carolina." The writer first saw it there, and was enabled, through the kindness of the State Commissioner, to gain possession of it.

An analysis of a small piece, cut from the mass with some difficulty, yielded Mr. J. B. Mackintosh the following results:* Iron, 85·33; nickel, 13·34; cobalt, 0·87; phosphorus, 0·16 = 99·70; sulphur and carbon in traces. Thus it is seen that in composition this mass of meteoric iron is of unusual interest, the percentages of nickel and cobalt being uncommonly high.

Fig. 1 shows the mass in its exact natural size, and exhibits well the natural appearance of the Widmannstätten figures brought out on this surface by etching with dilute nitric acid. The rough surface, surrounding the smooth, countersunk, etched panel, was purposely left in its original condition, so that the homogeneity of the mass could be readily seen. The extension of a few lines of the panel surface can be traced running over the rough exterior, and other lines are seen to be parallel when not continuous. The very apparent tendency of the perpendicular lines of this figure to form a right angle with the upper and lower sides, and a parallelism to the right and left hand edges, confirms the belief that we have, in this mass of meteoric iron, a well marked relation to a cuboidal form; a shape very rarely, if ever before, observed in masses of this nature.

Since the illustrations are made by a photo-engraving process (Ives'), we can look at them minutely and with satisfaction, knowing that nothing is misrepresented, or incorrectly drawn.

On five sides of this mass, an angle of 90° seemed to be very closely approximated, which tends to prove the form to be cuboidal by design rather than by accident. The other surfaces were either rounded, deeply pitted, or they presented the appearance of having been broken apart, by occult causes, from parts of the mass which are now lacking, these missing parts, possibly, completing the cuboidal form on all sides.

Fig. 2 represents part of a surface parallel to Fig. 1, but distant more than an inch from it, at the back of the mass. It is placed on the page in its natural relative position to Fig. 1, the lines in both figures being parallel.

Of special interest is the broad double line on the right-hand side of Fig. 2. From it, pointing upward at an angle of about 70° from the perpendicular, are seen lines, diverging right and left, at the same inclination, thus showing that twinning has occurred in this iron, parallel to an octahedral face. This broad line the writer has traced over the entire exterior of the mass, and identified it with the line in Fig. 1, situated two centimeters from the right-hand edge of the panel. The homogeneity is thereby clearly proved.

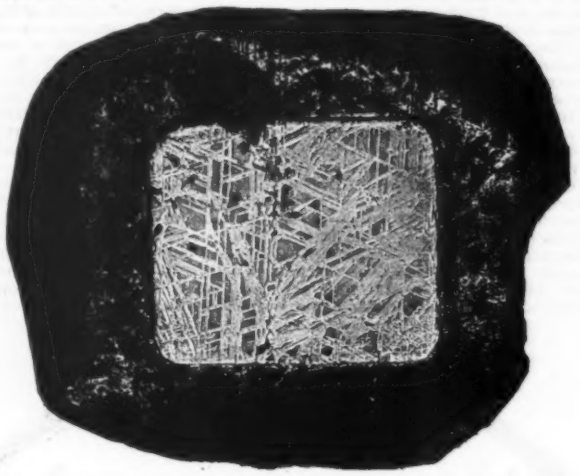


FIG. 1.—Meteoric Iron (Cuboidal), from Laurens County, S. C. (Natural size.)

The sharpness and general perfection of the Widmannstätten figures in this iron have seldom been equaled.

Fig. 3 represents a small surface situated at right angles to the lower right-hand edge of Fig. 1, and is, in the writer's opinion, the place of impact when this mass struck the earth. It is of interest to compare the fineness of these lines with those of the other figures; the parallelism of the lines to the longer straight edge—the cuboidal face—is also noteworthy.

The presence of hydrogen was proved by simply rubbing powdered sulphur over the smoothed surfaces, when, instantly, the disagreeable odor of hydrogen sulphide was made noticeable. In the action of nitric acid, carbon was also proved to be present, probably as graphite.

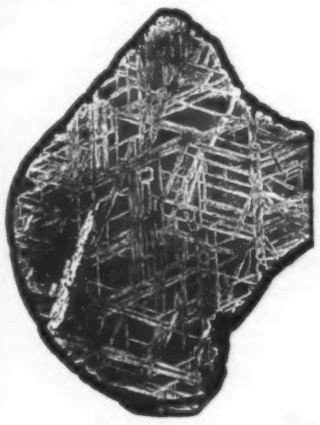


FIG. 2.—Widmannstatten Lines on the Laurens County, S. C., Meteoric Iron. (Natural size.)

Lawrencite (ferrous chloride) was noticed in the solid state, and in Fig. 2 the dark, rhomboidal spots represent the situation of this rare mineral in the mass.

This meteorite approaches that of Babb's Mill (Tennessee) and of Kokomo (Indiana) in its high nickel percentages, and in the fine development of the Widmannstätten figures to that of Smith Mountain (North Carolina), described by Smith and Kerr. It is the fourth meteorite found in South Carolina thus far, the others being known as the Bishopville (stone), Chesterville, and Ruff's Mountain (Lexington County) meteorites.

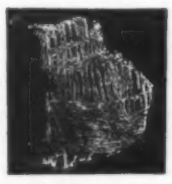


FIG. 3.—Laurens County, S. C., Meteoric Iron. (Transverse section.)

I here extend to Mr. Mackintosh my thanks for his kindness in making the analysis here given, and to Mr. R. W. Milner, of Laurens C. H., South Carolina, for his information as to the history of this very interesting mass of meteoric iron.

* Analysis completed June 24, 1885.

POTASSIUM ALCOHOLATE.—The author has obtained a compound which he names potassium alcoholate. The same name has been applied to compounds of alcohols and bases in which the metal is substituted for the hydrogen of the alcohol. To avoid confusion, he therefore proposes to reserve for these latter bodies the names of methylates, ethylates, etc.—*R. Engel, in Comptes Rendus*, vol. ciii., No. 2.

WIND AND BAROMETER.

THERE has been quite a lively discussion on this question, the past few weeks, in *Science*. This has brought out a number of interesting facts which I desire to briefly state and to add a few comments. This question is of much importance, as may be readily seen from the fact that a paper discussing it was read at the last meeting of the American Association for the Advancement of Science; and quite recently a statement has been published in *Nature* to the effect that at the high station Ben Nevis, in Scotland, the pressure is frequently lowered 0·10″ in high winds. The question is, Can the wind blowing across a chimney or by the side of a building produce a partial vacuum in the house sufficient to make an impression upon a barometer column? If we grant for a moment that an effect will be produced, what will be its nature and characteristics? Of course, the best possible answer to this question would be a few careful experiments under the above conditions. In lieu of these, it seems safe to assume that the direct effect would correspond to the cause, that is, since the wind does not blow steadily, the effect, if appreciable, would be more or less intermittent. The action of the wind is familiar to every one, and I think that all will admit that in most cases it is quite steady, with momentary lulls, but no absolute cessations. Just the period of the steady action and of the lull cannot be told by an ordinary Robinson anemometer, but may be told by one of Ossler's pattern, which acts by pressure and gives all the fluctuations. With these fluctuations in mind, we may consider that the effect of a high wind would be to depress the barometer column almost continuously, with occasional more or less sudden and momentary jumps at short intervals. These sudden jumps would hardly reach the actual air pressure before the end of the lull and the accompanying sudden fall.

In fact, it has been believed by some that it would be impossible to even determine that the wind has any effect at all except by closing up all communication with the room, noting the effect, then opening, noting the result, and so on until an absolute synchronism were established between the cause and the effect. In many very steady winds this would undoubtedly be true, but often it would seem as though the effect of the lull would be sufficiently marked to be noted by an observer with an ordinary aneroid or even a mercurial barometer. There is also an additional consideration relating to the situation of the chimney or other opening communicating with the room. If this were at the edge of a high wall, on the side of a sloping roof, or at the top of a tower, then it might happen that the effect of the wind would be re-enforced, so that the fluctuation would be due, not only to the blowing of the wind across the chimney, but also to a tendency to produce a partial vacuum by the air blowing up the inclined surfaces.

Let us turn to some of the facts that have been thus far developed. Mr. Clayton, of Blue Hill Observatory, near Boston, Mass., some 600 feet above sea level, has noticed some remarkable fluctuations in a self-recording barograph of Prof. Draper's pattern, and has been led to conclude that they were caused by a partial vacuum produced by the wind, as suggested above. This barograph was situated in the tower of a building at the summit of the hill. The fluctuations are traced by a pencil attached to a frame holding a barometer tube, which is suspended by two spiral steel springs about a yard in length. The tube of the barometer is free to move up and down, its lower end being immersed in a cistern of mercury, but not fastened to it in any way. With a wind above forty miles an hour, Mr. Clayton has noticed irregular fluctuations of the pressure trace, which in many instances have a period of two to five minutes from crest to crest of the wave-like oscillations. In many cases the amount of this fluctuation was over 0·05″, and in one case, about the time of opening a trap-door in the top of the tower, the trace shows a depression of 0·10″. In the last case, the time interval was over twelve minutes; it would be an interesting fact in this connection if we had given the time the trap-door was open. In *Science* for October 8, 1886, we find published a trace of this barograph for three hours, and very near the center of the three hours the above remarkable depression of 0·10″. A study of this trace shows the characteristics already noticed, that is, a wave-like appearance with a period of two to five minutes. We may add to this the fact that other barographs, of entirely different construction, show the same wave-like appearance, during high winds, differing only in degree from the one above. In some instances the trace is somewhat different from the one in *Science;* the trace with an electrical barograph shows a tendency to a movement above as well as below the general pressure line. Bearing in mind the principles laid down at the opening of this paper, we must conclude that there is nothing in common between this

wave-like appearance and what we might expect *a priori* from the probable nature of the effect of the wind.

In seeking for an answer to the question, What causes these fluctuations? we have the following considerations. Mr. Clayton says: "On this date (of the trace in *Science*) the up and down oscillations of the mercury in the standard Hicks barometer were so rapid that it was almost impossible to set the vernier accurately." If this shows anything, it shows that the waves on the trace and these rapid oscillations differed entirely from each other. It is probable that the rapid oscillations above alluded to can be simulated by stamping on the floor or striking the wall upon which the barometer is suspended, provided the tube is 0·75" or more in diameter. It would seem that these rapid movements are due partly to a shaking of the wall and partly to *short pulsations* caused by the wind, which probably would be magnified on opening the trap-door. In absence of actual experiment, which alone can settle this question, the following is suggested as an explanation of the abnormal trace. May not the long, coiled springs of the barograph have a definite period of oscillation, due to their elasticity and the inertia of the parts? In such case the shaking walls of the building and the short pulsations in the air would communicate a motion to the springs, and the amplitude and period of the waves in the barograph trace would be dependent upon the springs, and only indirectly upon the wind. This supposition is strengthened by the fact that in the case of our electrical barograph a slight alteration in one of the parts has caused these wave-like oscillations to entirely disappear. A few experiments will serve to prove or disprove the above hypothesis. It has seemed to me that the readers of the SCIENTIFIC AMERICAN might be interested in this subject, and not a few of them may be able to shed light upon it.

H. ALLEN HAZEN.

ON A DIAMANTIFEROUS PERIDOTITE, AND THE GENESIS OF THE DIAMOND.*

By Prof. H. CARVILL LEWIS, M.A., F.G.S.

THE discovery of diamonds at Kimberley, South Africa, has proved to be a matter not only of commercial, but of much geological, interest. The conditions under which diamonds here occur are unlike those of any other known locality, and are worthy of special attention.

The first diamond found in South Africa was in 1867, when a large diamond was picked out of a lot of rolled pebbles gathered in the Orange River. This led to the "river diggings" on the Orange and Vaal Rivers, which continue to the present time.

In 1870, at which time some ten thousand persons had gathered along the banks of the Vaal, the news came of the discovery of diamonds at a point some fifteen miles away from the river, where the town of Kimberley now stands. These were the so-called "dry diggings," at first thought to be alluvial deposits, but now proved to be volcanic pipes of a highly interesting character. Four of these pipes or necks, all rich in diamonds, and of similar geological structure, were found close together. They have been proved to go down vertically to an unknown depth, penetrating the surrounding strata.

The diamond-bearing material at first excavated was a crumbling yellowish earth, which at a depth of about 50 feet became harder and darker, finally acquiring a slaty blue or dark green color and a greasy feel, resembling certain varieties of serpentine. This is the well known "blue ground" of the diamond miners.

It is exposed to the sun for a short time, when it readily disintegrates, and is then washed for its diamonds. This "blue ground" has now been penetrated to the depth of 600 feet, and is found to become harder and more rock-like as the depth increases.

Quite recently, both in the Kimberley and De Beers mines, the remarkable rock has been reached which forms the subject of the present paper.

The geological structure of the district and the mode of occurrence of the diamond have been well described by several observers. As Griesbach, Stow, Shaw, Rupert Jones, and others have shown, the diamond-bearing pipes penetrate strata of Carboniferous and Triassic age, the latter being known as the Karoo formation.

The Karoo beds contain numerous interstratified sheets of dolerite and melaphyr, also of a Triassic age, and the whole reposes upon ancient mica schists and granites. The careful investigations of Mr. E. J. Dunn demonstrate that the diamond-bearing pipes inclose fragments of all these rocks, which fragments show signs of alteration by heat. Where the pipes adjoin the Karoo shales, the latter are bent sharply upward, and the evidence is complete that the diamond-bearing rock is of volcanic origin, and of post-Triassic age.

The diamonds in each of the four pipes have distinctive characters of their own, and are remarkable for the sharpness of their crystalline form (octahedrons and dodecahedrons) and for the absence of any signs of attrition. These facts, taken in connection with the character of the "blue ground," indicate, as Mr. Dunn has pointed out, that the latter is the original matrix of the diamond.

Maskelyne and Flight have studied the microscopical and chemical characters of the "blue ground," and have shown that it is a serpentinic substance containing bronzite, ilmenite, garnet, diallage, and "vaalite" (an altered mica), and is probably an altered igneous rock, the decomposed character of the material examined preventing exact determination of its nature. They showed that the diamonds were marked by etch figures analagous to those which Prof. Gustav Rose had produced by the incipient combustion of diamonds, and that the "blue ground" was essentially a silicate of magnesium impregnated with carbonates.

The "blue ground" often contains such numerous fragments of carbonaceous shale as to resemble a breccia. Recent excavations have shown that large quantities of this shale surround the mines, and that they are so highly carbonaceous as to be combustible, smouldering for long periods when accidentally fired. Mr. Paterson has shown that it is at the outer portions of the pipes, where the "blue ground" is most heavily charged with carbonaceous shale, that the richest yield of diamonds is found.

Mr. Dunn regards the "blue ground" as a decomposed gabbro, while Mr. Hudleston, Mr. Rupert Jones, and Mr. Davies regard it as a sort of volcanic mud. Mr. Hudleston considers that the action was hydrothermal rather than igneous, the diamond being the result of the contact of steam and magnesian mud under pressure upon the carbonaceous shales, and likens the rock to a "boiled plum pudding."

The earlier theories as to the origin of the diamond have, in the light of new facts, quite given way to the theory that the diamonds were formed in the matrix in which they lie, and that the matrix is in some way of volcanic origin, either in the form of mud, ashes, or lava.

The exact nature of this matrix becomes, therefore, a matter of great interest. The rocks now to be described are from the deeper portions of the De Beers mine, and were obtained through the courtesy of Mr. Hedley. They are quite fresh and less decomposed than any previously examined. Two varieties occur, the one diamantiferous, the other free from diamonds, and the lithological distinction between them is suggestive. The diamantiferous variety is crowded with included fragments of carbonaceous shale, while the non-diamantiferous variety is apparently free from all inclusions, and is a typical volcanic rock.

Both are dark, heavy, basic rocks, composed essentially of olivine, and belong to the group of peridotites. Both are of similar structure and composition, differing only in the presence or absence of inclusions. The rock consists mainly of olivine crystals lying porphyritically in a serpentinic ground-mass.

The olivine is remarkably fresh, and occurs in crystals which are generally rounded by subsequent corrosion. The principal accessory minerals are biotite and enstatite. The biotite is in crystals, often more or less rounded, and sometimes surrounded by a thin black rim due to corrosion. Similar black rims surround biotite in many basalts. The biotite crystals are usually twinned according to the base. The enstatite is clear and non-pleochroic. Garnet and ilmenite also occur, the latter often partly altered to leucoxene. All these minerals lie in the serpentinic base, originally olivine. This rock appears to differ from any heretofore known, and may be described as a dunite porphyry or saxonite porphyry.

The diamond-bearing portions often contain so many inclusions of shale as to resemble a breccia, and thus the lava passes by degrees into tuff or volcanic ash, which is also rich in diamonds, and is more readily decomposable than the denser lava.

It seems evident that the diamond-bearing pipes are true volcanic necks, composed of a very basic lava, associated with a volcanic breccia and with tuff, and that the diamonds are secondary minerals produced by the reaction of this lava, with heat and pressure, on the carbonaceous shales in contact with and enveloped by it.

The researches of Zirkel, Bonney, Judd, and others, have brought to light many eruptive peridotites, and Daubree has produced artificially one variety (lherzolite) by dry fusion, but this appears to be the first clear case of a peridotite volcano with peridotite ash.

Perhaps an analogous case is in Elliot County, Kentucky, where Mr. J. S. Diller has recently described an eruptive peridotite which contains the same accessory minerals as the peridotite of Kimberley, and also penetrates and incloses fragments of Carboniferous shale, thus suggesting interesting possibilities.

* Abstract of a paper read at the Birmingham meeting of the British Association for the Advancement of Science, September, 1886.

ORNAMENTAL GRASSES.

MEMBERS of the grass family belonging to England do not, as a rule, reach a great height, but in tropical climes they assume gigantic proportions, some of them attaining to 50 feet, 60 feet, and even 100 feet in height, rivaling the palms in stature and resembling them in structure. For the decoration of the lawn and wild garden the material in the way of grasses from which to select is ample; the difficulty is what to choose and what to avoid. The following enumeration contains species calculated to add grace and beauty to our gardens.

The Arundo, or reed grass, as now understood, does not include any species indigenous to this country. All of them are tall, handsome grasses, attaining a height of from 6 feet to 10 feet, and should be introduced into every garden where there is the slightest possibility of their thriving. A. conspicua resembles a small form of pampas grass. It commences to flower in July, and is therefore a desirable acquisition; it is hardier than the pampas, which should have its crowns protected in winter. Besides A. conspicua, there are A. Donax and Donax versicolor.

Arundinaria.—This genus is nearly allied to Bambusa. A. falcata has been planted somewhat extensively in Ireland, where it thrives admirably and attains a height of 20 feet. It has also been found to grow well in the south and southwest of England. Its graceful growth should lead to its being planted very largely everywhere. There is another very fine species, A. schomburghi, a native of the Upper Amazon, which grows some 50 feet or more in height. This should be a grand ornament, planted in isolated groups upon the lawn, if we could only get it introduced. In 1862 I received specimens from Nagasaki of a very fine feathery grass, supposed to be a species of Arundinaria. It grows 10 feet in height, and is said to prove good for planting in tufts like the pampas grass. In Japan it has a fine effect on the hill-sides in November and December. Let us hope this may soon be introduced.

Agrostis, or bent grass (A. vulgaris), is a troublesome weed upon light lands, but useful for covering dry, sandy banks where but little else will grow. There are in this genus some extremely beautiful species, varying in height from 1 foot to 3 feet. Some of the smaller kinds are suitable for pot culture, and are well adapted for working into button holes and shoulder sprays. The best are A. capillaris, diffusa, dulcis, nebulosa, pulchella, verticillata, vulgaris vivipara, and vulgaris variegata.

Aira, or hair grass, is a widely distributed family. A. cæspitosa is one of the tallest of our English grasses, often attaining a height of 6 feet. It is not only very ornamental in isolated groups, but useful as a cover for game. It is, however, troublesome in pasture land. The best are A. cæspitosa, cæspitosa vivipara, lutescens, and pulchella.

The genus *Andropogon* contains many fine ornamental species. A. schœnanthus, the lemon grass, deserves a passing notice, although too tender to be used in the open air. An infusion of its leaves is said to be useful in cases of fever, while from its fibrous roots and from those of another species (A. muricatus) mats and fans are made in India, which impart an agreeable fragrance to the atmosphere where used. Although none of the species can be said to be thoroughly hardy, they amply repay any attention bestowed upon them. The best are A. bombycinus, formosus, and squarrosus.

Bamboos in their native habitats often attain a height of 100 feet. Their economic properties are well nigh inexhaustible, and in a decorative point of view they cannot be overestimated, their elegant, feathery spray giving a distinct and tropical appearance to any garden in which they are grown. The kinds enumerated below vary from 6 feet to 20 feet in height, and form grand groups upon the lawn, or indeed in any sheltered position. They enjoy a free, rich, open soil. The best are B. aurea, nigra, edulis, Metake, Simoni, Fortunei, striata, violacea, viridis, and viridis glaucescens.

The Broom Grass, a very large genus widely distributed, contains some seven or eight species indigenous to England, and among them one or two make beautiful garden ornaments, especially when grown in good rich soil. The best are Bromus brizopyroides, diandrus, hirsutus, jubatus, lanuginosus, macrostachys, schraderi, scoparius, and vestitus.

Of Briza, or quaking grass, some of the species are handsome and well deserve attention. Two are British, viz. media, which is widely distributed and much sought after for winter decoration, and minor, which is local. They are useful either in pots or in the border. B. gracilis, maxima, media, and virescens are the best.

Brizopyrum—This is a small genus of handsome and singular grasses, none of which are indigenous. They range from 1 foot to 4 feet in height, and are mostly from the Southern Hemisphere. The best are B. siculum and scirpoides.

Coix (Job's Tears).—This genus has obtained its popular name from the supposed resemblance of its pendent hanging seeds to dropping tears. C. lachryma is a broad-leaved, handsome plant which thrives well in the open air, in a warm sheltered spot. It is also very ornamental when grown as a pot plant. It requires an abundant supply of water, otherwise the leaves are apt to become brown or rusty looking.

Dactyloctenium.—This genus contains a few distinct and ornamental plants which grow from 1 foot to 2 feet high, most of them annuals; they produce dense finger-like spikes of flowers, all pointing one way. As pot plants, they are very elegant, but rather tender for open air. D. ægyptiacum and radulans are the best of them.

Digitaria (finger grass) is a genus containing handsome plants, mostly natives of the south of Europe, the inflorescence of which is produced on long finger-like spikes; they grow from 1 foot to 2 feet or more in height, and are very suitable for the fronts of mixed borders. They thrive best on a light sandy soil. The best are D. ciliaris, sanguinalis, and villosa.

Dichelachne.—Under this name I have grown a very handsome grass, which makes dense tufts some 2 feet or more in height, and is furnished with a beautiful feathery inflorescence. It is a native of New Zealand, and is perfectly hardy. It is named D. crinita.

Elymus is a genus containing about half a hundred species, two of which are natives, viz., E. arenarius, the sea lyme grass, which grows about 3 feet high, and is useful for planting by the sea-side; and E. geniculatus, the jointed lyme grass, a kind of great service for planting on dry, gravelly inland warrens and game preserves. Some of the exotic kinds are very effective, although somewhat coarse. Among them E. crinitus, condensatus, Caput Medusæ, and giganteus are the best.

Erianthus.—As a genus this is nearly allied to saccharum. E. ravennæ forms large, dense tufts, similar to those of Arundo conspicua, and should be grown, if only for its foliage, but it produces in addition large handsome panicles of bloom, which rise to upward of 6 feet in height. This plant requires a light loamy soil and a southern aspect.

The Pampas Grass is too well known to need description. It forms a bold, isolated mass, the flower spikes from which rise some 10 feet or 12 feet in height. Unfortunately, its handsome plumes often get damaged by wet. I am under the impression that when first introduced it bloomed earlier than now. The West Indian G. saccharoides is a grand species, producing noble silvery plumes, but as far as I know it has not yet been introduced.

The Lagurus, or hare's-tail, is a useful grass, found somewhat sparingly in Guernsey. L. ovatus, which is an annual, grows from 8 inches to 18 inches high, and produces roundish, soft white, spike-like panicles of flowers, ornamented with long beards. It is useful either in pots or in borders.

Melica.—The species belonging to this genus are widely distributed; two are natives of Britain, but very few of them are worth cultivating. M. nutans, however, is worthy of note, being one of the few grasses that thrive under the shade of trees. M. altissima makes a good garden ornament. It grows from 2 feet to 4 feet in height, and produces dense racemes of flowers, with large shining glumes.

The Blue Moor Grass (Molinia) is an indigenous plant and very effective in the front row of a mixed border. It also makes a good bog plant. Its leaves are about 8 inches high, and its branching panicles often extend a foot above them. The best are M. cærulea and cærulea variegata.

Panicum.—In this genus are large, bold, and, in some instances, gigantic grasses. They are widely distributed throughout the tropical and sub-tropical portions of the globe, but many of them are sufficiently robust in constitution to withstand our climate in summer. Dotted upon the lawn or grouped in masses in the sub-tropical garden, they form grand ornaments. They enjoy good, rich, loamy soil. The best are P. altissimum, aurantiacum, bulbosum, clandestinum, capillare, miliaceum, and virgatum.

Pennisetum longistylum and *setosum* are handsome plants either for indoor decoration or for the mixed border. Their bearded heads of flower somewhat resemble those of Hordeum jubatum, but more dense and soft in texture. The species are widely distributed

through sub-tropical countries, growing usually from 1 foot to about 3 feet high.

Paspalum scrobiculatum and *stolonifernm* are highly decorative and beautiful grasses. They grow some 2 feet in height, and bear their inflorescence in long dense spikes; in some species it is digitate, in others alternate.

Phalaris, or Canary grass.—The species of this genus are mostly annuals, and very elegant. They are natives of Central Asia. Some fifteen or twenty are recorded, but among them there is great sameness; they form beautiful masses either in the wild garden or mixed border. P. arundinacea is perennial, its variegated form being known as gardener's garter. The best known are P. aquatica, arundinacea, variegata, brachystachys, canariensis, and cærulescens.

Phragmites, known also as Arundo Phragmites, is the largest of our British grasses. It is very ornamental placed beside rivers or lakes, where it grows upward of 6 feet in height, while its creeping roots afford material protection to the banks by binding the earth together.

The Sorghums are bold and effective plants for isolating on lawns, or for massing in the sub-tropical garden; their broad, handsome leaves and large dense panicled inflorescence make them conspicuous. S. halepense is perennial and hardy, but the majority of the species are annuals. Their seed, under the name of millet, is largely used for poultry feeding, but it does not appear to ripen in this country so as to be profitable. The best are, in addition to halepense, bicolor, rubens, and vulgare.

Stipa, or feather grass.—A large genus, in which, however, few species possess any beauty when out of flower, and their feathery panicles are but short lived. Plants of this grass are usually grown in quantity, in order that the panicles may be cut and preserved for winter decoration. S. pennata is the species mostly employed for this purpose; but S. juncea and tortilis are also attractive grasses.

Maize (*Zea*).—This is an effective plant, but we have heard objections raised by some to its introduction into the flower garden. To me it matters little what the plants used there are, provided the desired effect is produced, and the tropical appearance of this plant ought to secure it a place there. It should be planted in a warm sheltered position and in rich soil. The variegated form is a charming addition to the garden. It is not quite so robust as the type, but it grows freely in the open air, even close to the sea. It comes true from seed, from which it is easily raised in spring. It should not, however, be planted out until properly hardened off.—*W. H. G., The Garden.*

PASTURING OR STALL-FEEDING.

MEN usually honestly differ in their opinions upon subjects because of the different standpoints from which they obtain their views. A farmer with a large, fertile pasture well sodded with grasses that yield continuous feed through the entire summer is not likely to be a very strong advocate of the soiling or stall-feeding system for keeping milch cows, fattening steers, or breeding stock of any kind. He finds it a great deal easier to drop the pasture bars or open the cow yard gate every morning, and let the stock through to feed at their leisure, than to start out with scythe or corn cutter and cart or wheelbarrow for a day's rations for his animals.

The editor of the *American Dairyman* probably spent his boyhood farm days on a farm where there were good and cheap pastures, for he makes lots of fun of the men who advocate soiling, and guesses that such advocates are chiefly professors at colleges, who sit in their easy chairs and figure out the profits of the system on paper. He also ventures the prediction that "there is not a baby in its crib to-day so young that it will live to see the day that soiling will be popular in any of the States in this Union."

Now, the fact in this case is that soiling, such as the *Farmer* has long recommended, is popular to-day, not only in these old New England States, but is growing so even at the West, where land is supposed to be both cheaper and richer than it is at the East. Some of the most successful dairymen in the great prairie States are strong advocates of feeding cows more or less in the summer on crops cut and carried to them in their stalls. They find that they can keep double the stock that farmers usually keep who pasture exclusively. They also learn that there is a great saving of manure, and of fencing too, if the system is extensively adopted. They learn, too, that their cows give a more uniform flow through the season, and retain their flesh better. Their cows are never starved in a dry period, nor bloated when the feed is over-luxuriant, nor are they pestered by flies as when running in the pastures in hot weather. This of course presumes that ample preparation is made for a succession of field crops through the entire summer and good, comfortable stables, sheds, or yards for the cows to eat and lie in.

We have never been an advocate of indiscriminate full soiling, but would recommend such a system for each farmer as will best fit his own particular case. If one has a good pasture, it would certainly be the height of folly not to use it; and if one has pasture land that is too rocky to cultivate, it should be kept in pasture or wood permanently. There are pastures that can hardly be excelled as the home for breeding stock during the summer, pastures that are nearly always green and tolerably free from flies and well watered. We have seen many such in Vermont and a few in New Hampshire, Connecticut, and other States, but such pastures are the exception rather than the rule. Most farmers find themselves short of feed in a dry time, and their cows shrinking in flow and in flesh. Something can be done to help the matter by giving daily rations of some kind of grain, and hay or other dry fodder may be fed, but these are but steps toward the soiling system. It is feeding in the stall instead of the pasture exclusively. Few people who have not observed closely, realize how much it costs to support a swarm of flies in our cow pastures in summer. They suck the blood which should go to the manufacture of milk, and they keep the cows laboring with every muscle of the body enough to equal, with the mental annoyance, a pretty good day's work at the plow or thrashing machine. A neighbor of ours who keeps but one cow occasionally calls upon the writer to milk her at night when he is away. The cow usually runs in a first-class pasture, but on such days, to save us trouble, he keeps her in the barn and has her fed on green food or hay given in her manger. Although a change of milkers is usually attended by more or less shrinkage, he informs us that the cow invariably, in fly time, gives more when kept up than her usual quantity; and every one knows, or ought to, that milk from quiet cows is richer than that from cows that are worked or worried.

We agree with the *Dairyman* that the director of the Ohio Station may be a little over-sanguine in his predictions, when he says the time is not far distant when nearly all the food of the cattle in his State will be cut and carried to them. We do not expect to see all the farmers in any State first-rate farmers for some time to come. It would be expecting too much. Yet we do not know how soon low prices and close competition may compel farmers to adopt more economical methods. Soiling has become popular in some of the best farming sections of Europe already, and must become so elsewhere just as fast as circumstances and conditions make it so. Most men are too lazy to do very much work till they see the necessity for it. On our own farm of about thirty acres we found soiling a necessity if there was any money to be made by stock husbandry; and so thoroughly have we been converted to the system, not by figuring out the profits on paper while sitting in an easy chair, but by actual practice, growing and feeding crops and carting out the manure to the fields, that we are almost sure we would follow the system were we to locate on the best dairy lands in Vermont or elsewhere. Our experience and observation has taught us that the bane of American agriculture has been too much land. Our fathers did not all have too much when it was virgin fertility they were carrying off, it made them rich, but the system has made their children poor, for the children have followed the habits of the fathers, and handled large areas after the fertility has gone out from the land. Our fathers may have left the world better for their living in it, but they did not leave the land better, nor can we by following the old system. The man who sets out to buy a farm and practice soiling may save one-half his money at the outset by buying only one-half the usual number of acres supposed to be needed for a herd of dairy cows. He will thus save half his taxes and half his interest account. He may also make a great saving in his fencing expenses. From these several sources of saving we can see a pretty fair annual income on a moderate investment.

It is actually impossible in ordinary dairying sections for one to obtain the full use of his capital by following the pasturing system exclusively. In a climate so variable and uncertain as ours, it will never do to stock a pasture to its full capacity in favorable weather, for fear of a short supply of feed in case of dry weather coming on later. So the farmer who pastures exclusively must let his feed waste or buy and sell stock with every material change of weather, a thing next to impossible where his neighbors are all similarly affected. The stall-feeding system practically insures against such losses and annoyances. To us the case seems so clear as to require no argument.

While we are writing these lines we find another experiment station professor figuring out the possibilities of the two systems. We refer to the report of Prof. W. A. Henry, of the Wisconsin Station, who last summer kept six cows, three by pasturing and three by soiling, having the quality of the two herds as nearly equal as possible. The result was a product of 1,779 pounds of milk from one acre of pasture, producing 82 pounds of butter, while one acre in soiling crops gave him 4,782 pounds of milk, which made 196 pounds of butter. The pasture was one of the best blue grass pastures, capable of carrying a cow per acre through the season under favorable weather conditions.

In conclusion, we would hazard the assertion, based upon our own observation throughout New England, that already more than one-half of the successful dairymen practice soiling or stall-feeding to a greater or less extent, and do not depend solely upon pasture feed from the opening to the closing of the season. We recommend, however, the advice of the *Dairyman* to beginners to "start easy on a small scale, and increase or decrease crops or pasture as they find it pays."—*N. E. Farmer.*

HYDROPHOBIA TREATED WITH SUBLIMATE AND ATROPINE.

FRANCESCO MANCO, a countryman, fifty-two years old, had, on May 10, his fore arm and left leg bitten by a rabid bitch. The bitch was killed a little while after, and Manco did not feel any effect from the bite till July 28.

On the evening of that day, coming back to his village from Nola, Manco was seized with convulsions and a feeling of suffocation. When he got home, the sight of some water augmented his agitation to the highest degree of convulsive intensity.

He was conducted to the "Ospedale degli Incurabili," in Naples, and subjected to the treatment of the young physician, Mr. De Capua.

The patient was in a serious condition. The sight of water, a draught of air, threw him into terrible spasms. He trembled with cold.

Dr. De Capua thought, basing his reasons on the eminently parasiticidal efficacy of sublimate (protochloride of mercury), to operate upon the patient with abundant injections of that liquid; and, after Professor Pellecchia's authorization, he began directly to inject at several times.

According to the theoretical conceit of the *virus rabico*, Dr. De Capua thought also to depress the highest symptoms of hydrophobia, and thus the risk of immediate death, alternating the injections of sublimate with those of atropine.

The young physician succeeded, because, having depressed the paroxysms by these injections, the horrible spasms ceased; and, to their astonishment, the patient was able to drink a full glass of water, the sight of which would have been enough, a little while before, to exasperate him.

From that day he got better, so that they dared hope for his recovery, as the culminating symptoms of hydrophobia were over.

The patient spontaneously demanded something to eat, and on August 20 swallowed, without difficulty, before us, a full glass of wine at a breath.

The delirium had three different characters. At first, that of *persecution*, in which the patient seemed to see around him every sort of peril and menace; after, the professional character, in which he thought he was in his village, and occupied with his habitual work; at last the delirium assumed the mystic form, and then an important graduation of calm, because under that character the patient was only singing the litany the whole day.—*Il Piccolo, Naples.*

POISONING BY ANILINE.

IN France, iron filings and acetic acid are generally employed for producing the hydrogen required for the reduction of nitro-benzol to aniline. In Sott Baie, a well-known firm had been using hydrochloric acid instead of acetic acid, and had obtained a quantity of hydrochloric acid from Giessen, said to have been made with strongly arsenical sulphuric acid. The arsenic chloride present was converted in the process into arsenic hydride. The lives of five of the workmen were saved with great difficulty. The question is raised whether coal-tar colors may not be rendered poisonous in this manner, though no arsenic acid has been knowingly used in their manufacture.—*M. Bruhat, in Journ. de Pharm.*

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